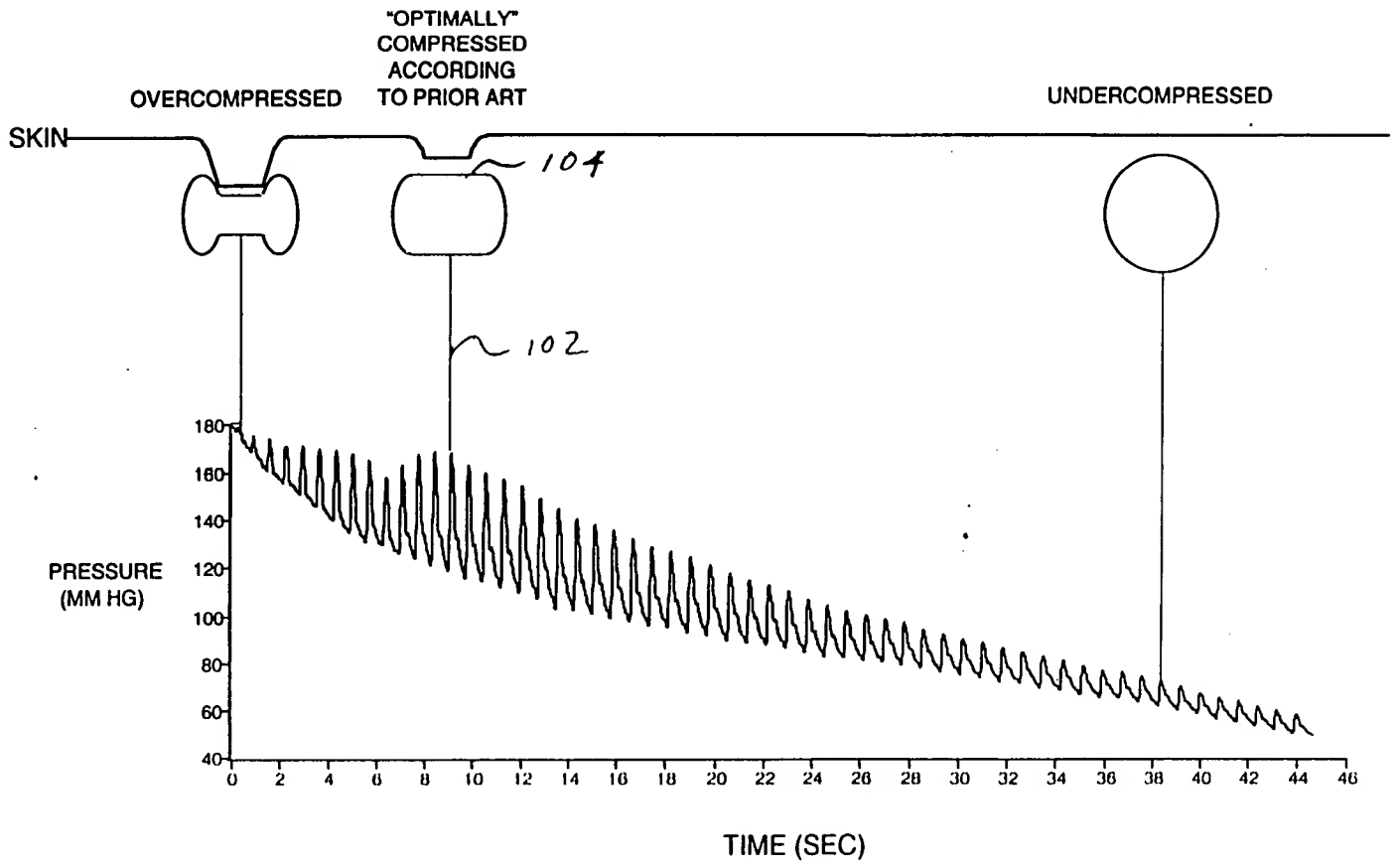


FIG. 1
(PRIOR ART)

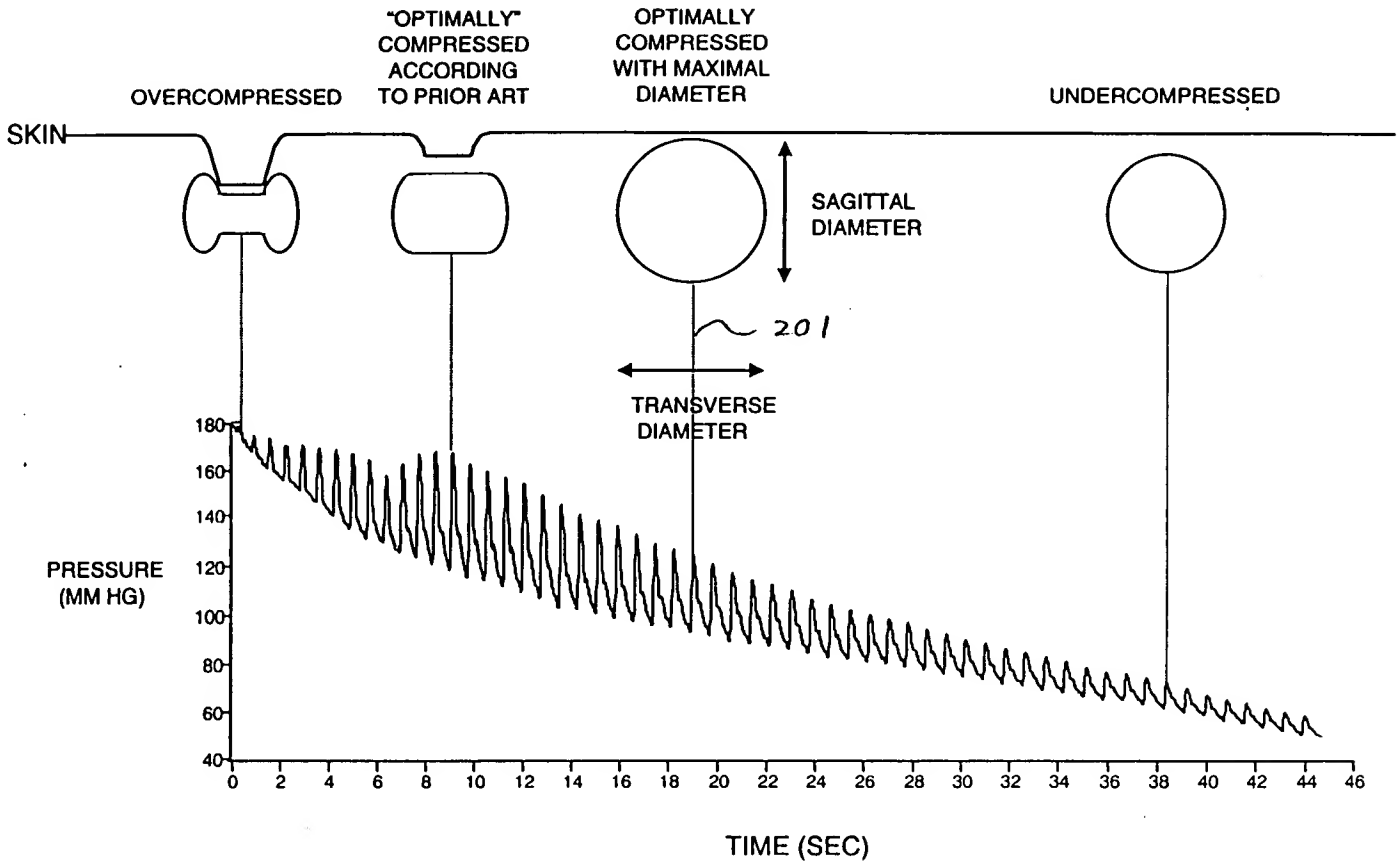

"OPTIMALLY" COMPRESSED ACCORDING TO PRIOR ART
OPTIMALLY COMPRESSED WITH MAXIMAL DIAMETER
OVERCOMPRESSED
UNDERCOMPRESSED
SKIN
SAGITTAL DIAMETER
201
TRANSVERSE DIAMETER
PRESSURE (MM HG)
180
160
140
120
100
80
60
40
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
TIME (SEC)

FIG. 2

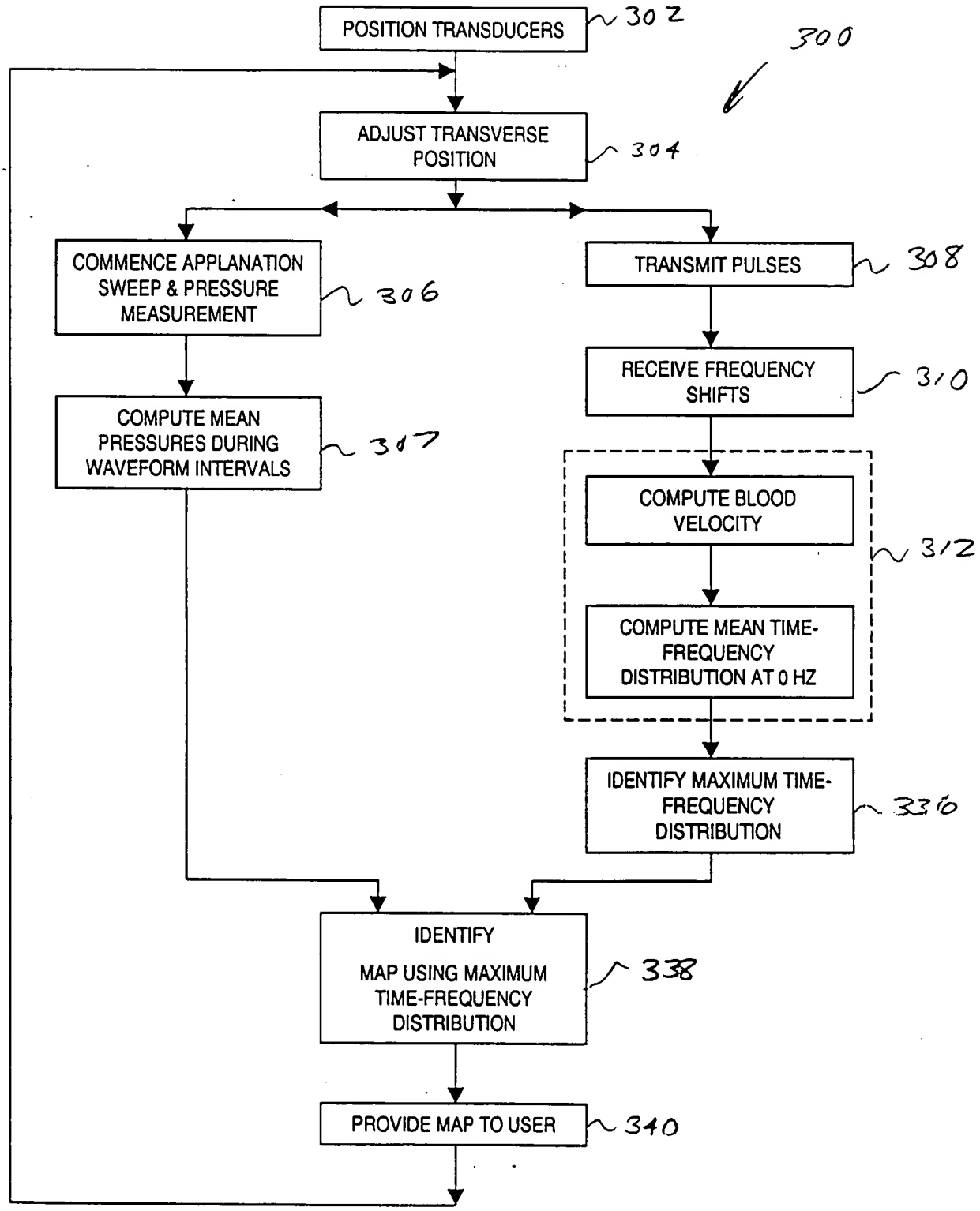

POSITION TRANSDUCERS
302
300
ADJUST TRANSVERSE POSITION
304
COMMENCE APPLANATION SWEEP & PRESSURE MEASUREMENT
306
TRANSMIT PULSES
308
RECEIVE FREQUENCY SHIFTS
310
COMPUTE MEAN PRESSURES DURING WAVEFORM INTERVALS
317
COMPUTE BLOOD VELOCITY
312
COMPUTE MEAN TIME-FREQUENCY DISTRIBUTION AT 0 HZ
IDENTIFY MAXIMUM TIME-FREQUENCY DISTRIBUTION
316
IDENTIFY
MAP USING MAXIMUM TIME-FREQUENCY DISTRIBUTION
318
PROVIDE MAP TO USER
320

FIG. 3A

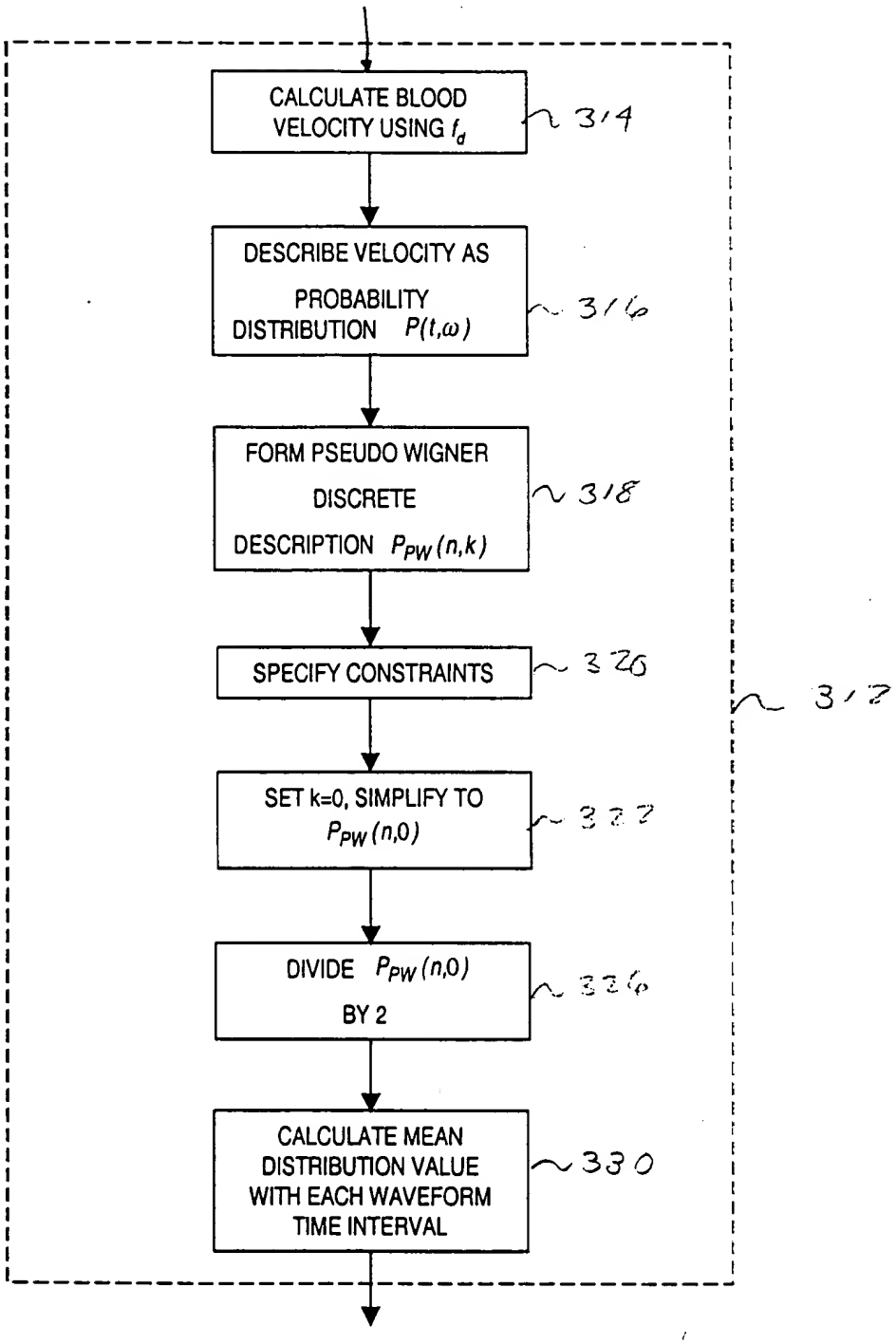

CALCULATE BLOOD VELOCITY USING f_d
314
DESCRIBE VELOCITY AS PROBABILITY DISTRIBUTION $P(t,\omega)$
316
FORM PSEUDO WIGNER DISCRETE DESCRIPTION $P_{PW}(n,k)$
318
SPECIFY CONSTRAINTS
326
SET k=0, SIMPLIFY TO $P_{PW}(n,0)$
327
DIVIDE $P_{PW}(n,0)$ BY 2
326
CALCULATE MEAN DISTRIBUTION VALUE WITH EACH WAVEFORM TIME INTERVAL
330
312

FIG. 3b

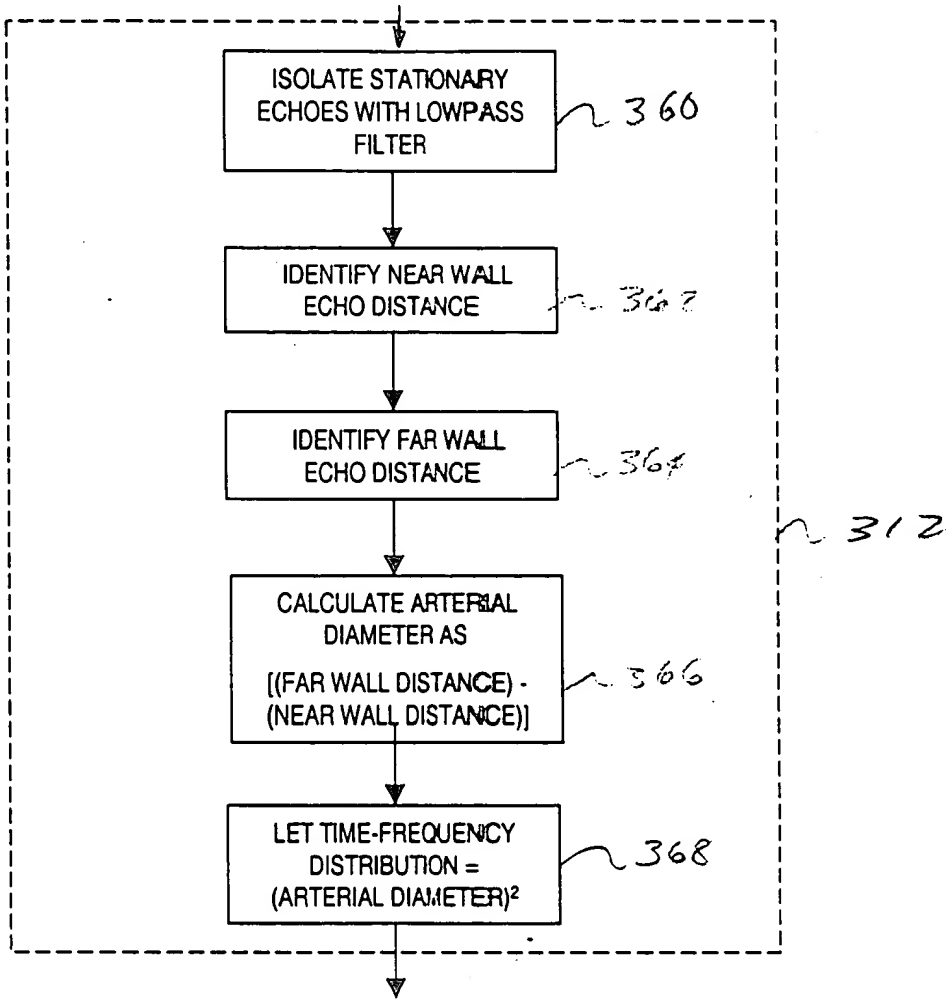

ISOLATE STATIONARY ECHOES WITH LOWPASS FILTER
360
IDENTIFY NEAR WALL ECHO DISTANCE
362
IDENTIFY FAR WALL ECHO DISTANCE
364
312
CALCULATE ARTERIAL DIAMETER AS
[(FAR WALL DISTANCE) - (NEAR WALL DISTANCE)]
366
LET TIME-FREQUENCY DISTRIBUTION = (ARTERIAL DIAMETER)²
368

FIG. 3C

Fig. 4a

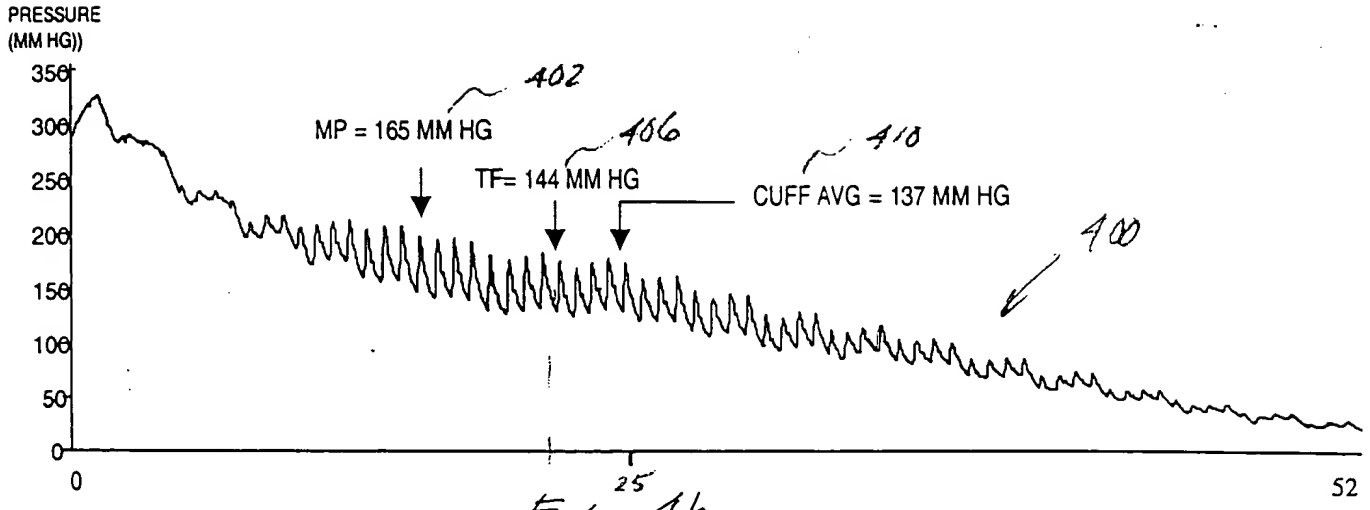


Fig. 4b

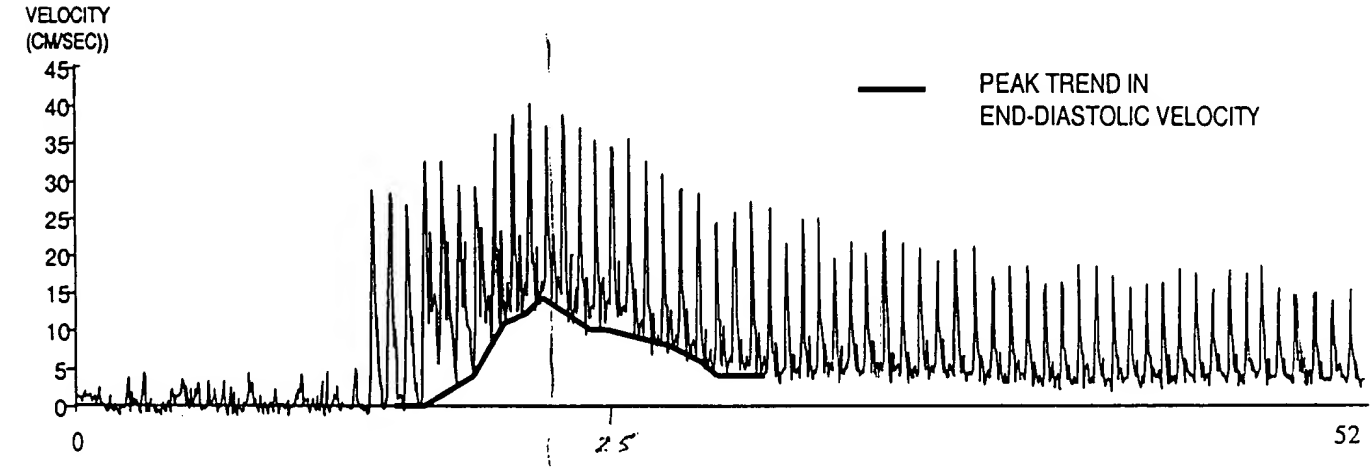


Fig. 4c

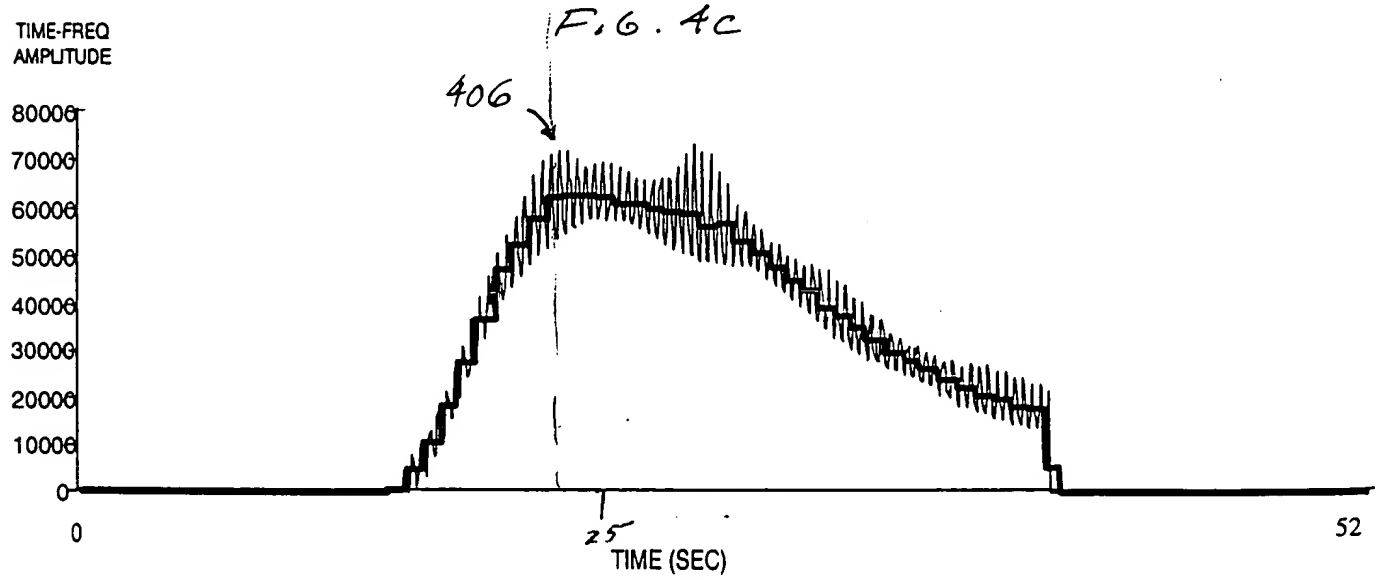


Fig. 5a

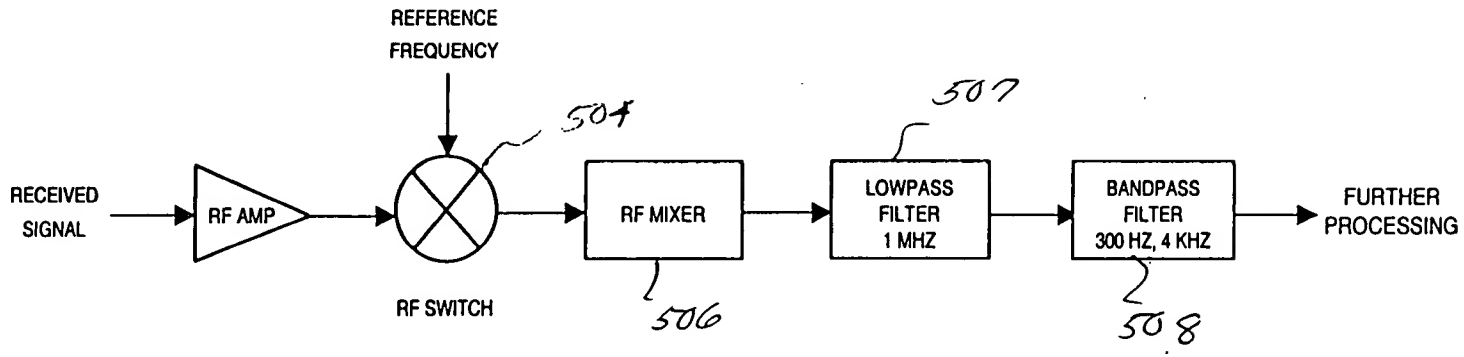
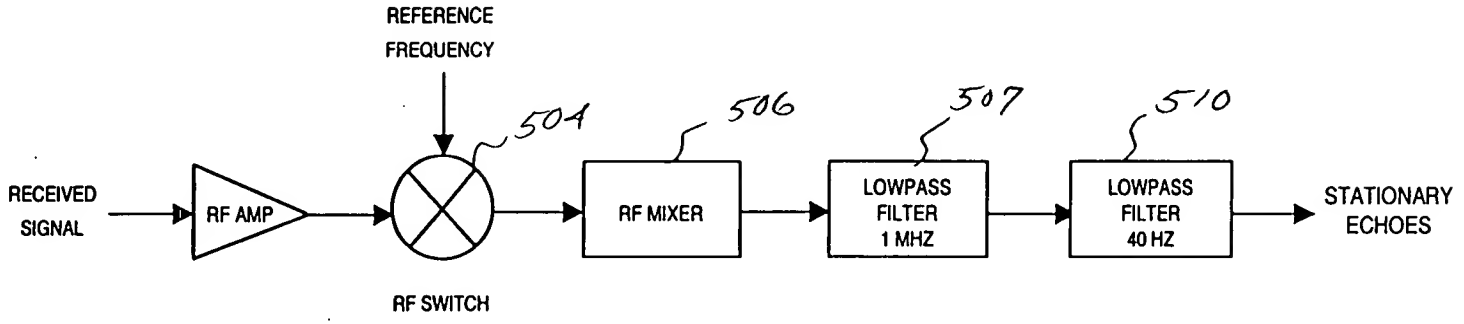
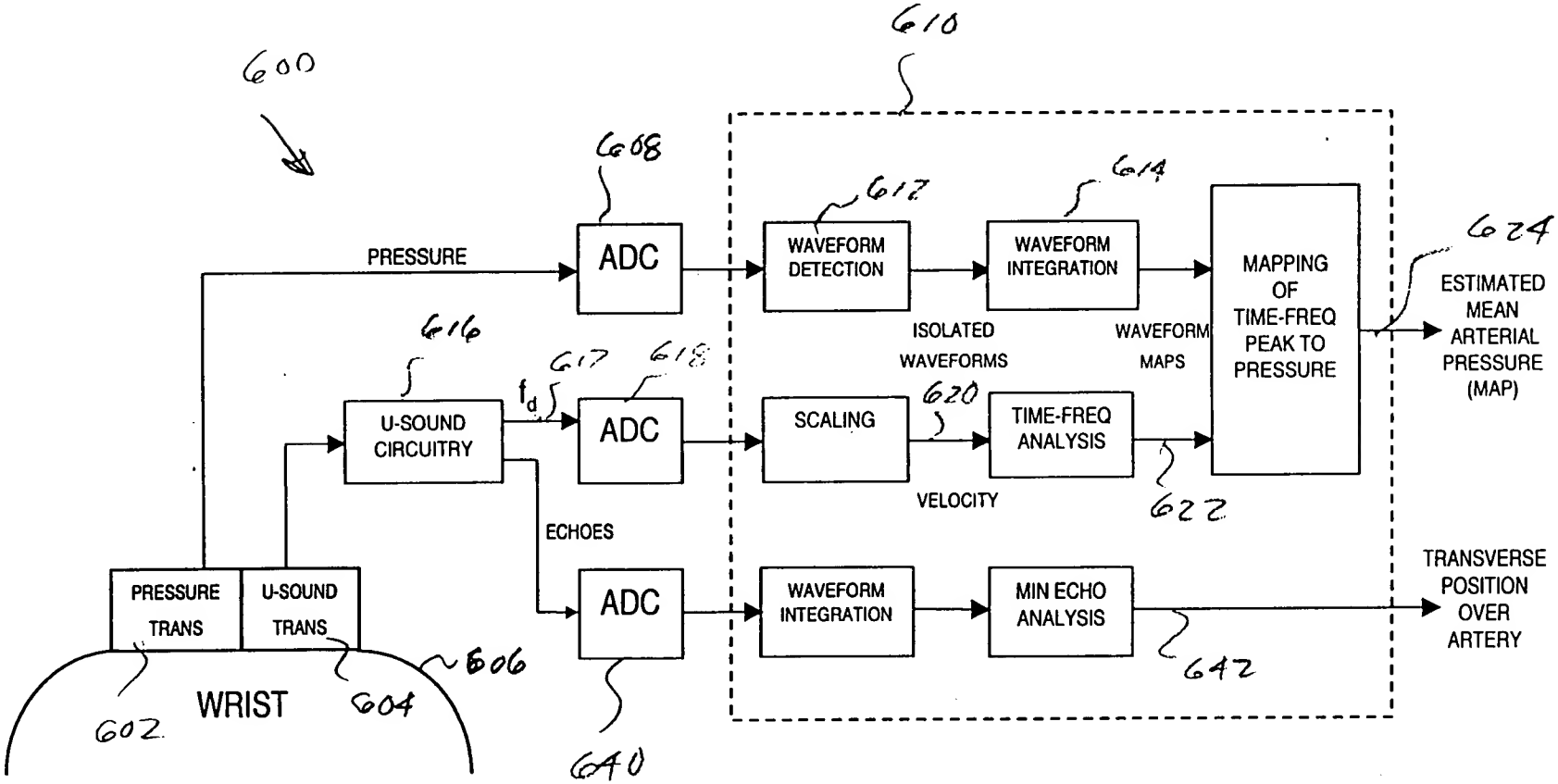

REFERENCE
FREQUENCY
504
507
RECEIVED
SIGNAL
RF AMP
RF MIXER
LOWPASS
FILTER
1 MHZ
BANDPASS
FILTER
300 HZ, 4 KHZ
FURTHER
PROCESSING
RF SWITCH
506
508

Fig 5b


REFERENCE
FREQUENCY
504
506
507
510
RECEIVED
SIGNAL
RF AMP
RF MIXER
LOWPASS
FILTER
1 MHZ
LOWPASS
FILTER
40 HZ
STATIONARY
ECHOES
RF SWITCH


600
610
608
617
614
624
PRESSURE
ADC
WAVEFORM DETECTION
WAVEFORM INTEGRATION
MAPPING OF TIME-FREQ PEAK TO PRESSURE
ESTIMATED MEAN ARTERIAL PRESSURE (MAP)
ISOLATED WAVEFORMS
WAVEFORM MAPS
616
617
618
f_d
620
U-SOUND CIRCUITRY
ADC
SCALING
TIME-FREQ ANALYSIS
VELOCITY
622
ECHOES
TRANSVERSE POSITION OVER ARTERY
PRESSURE TRANS
U-SOUND TRANS
606
WRIST
602
604
ADC
WAVEFORM INTEGRATION
MIN ECHO ANALYSIS
642
640

F.16. 6

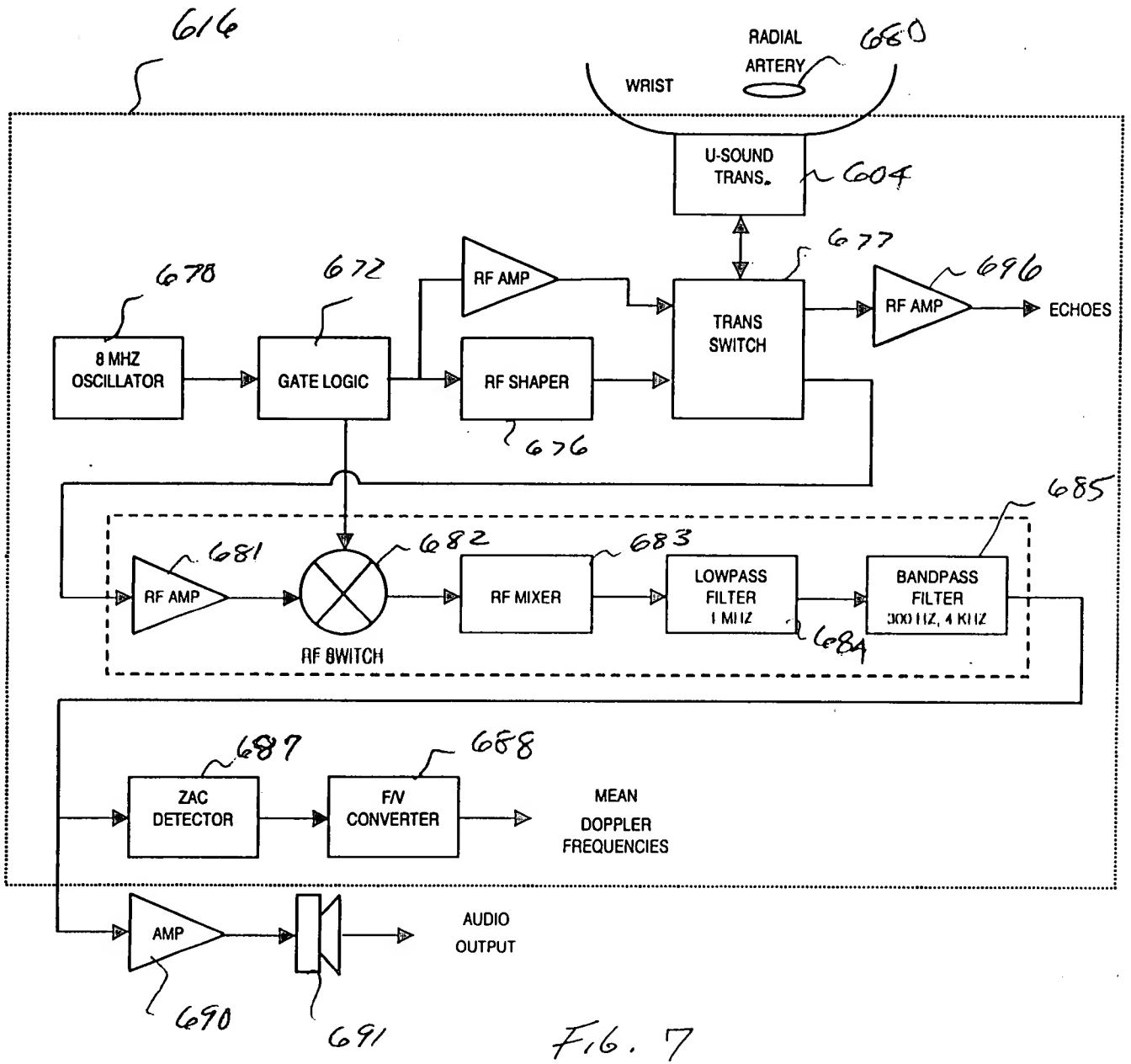
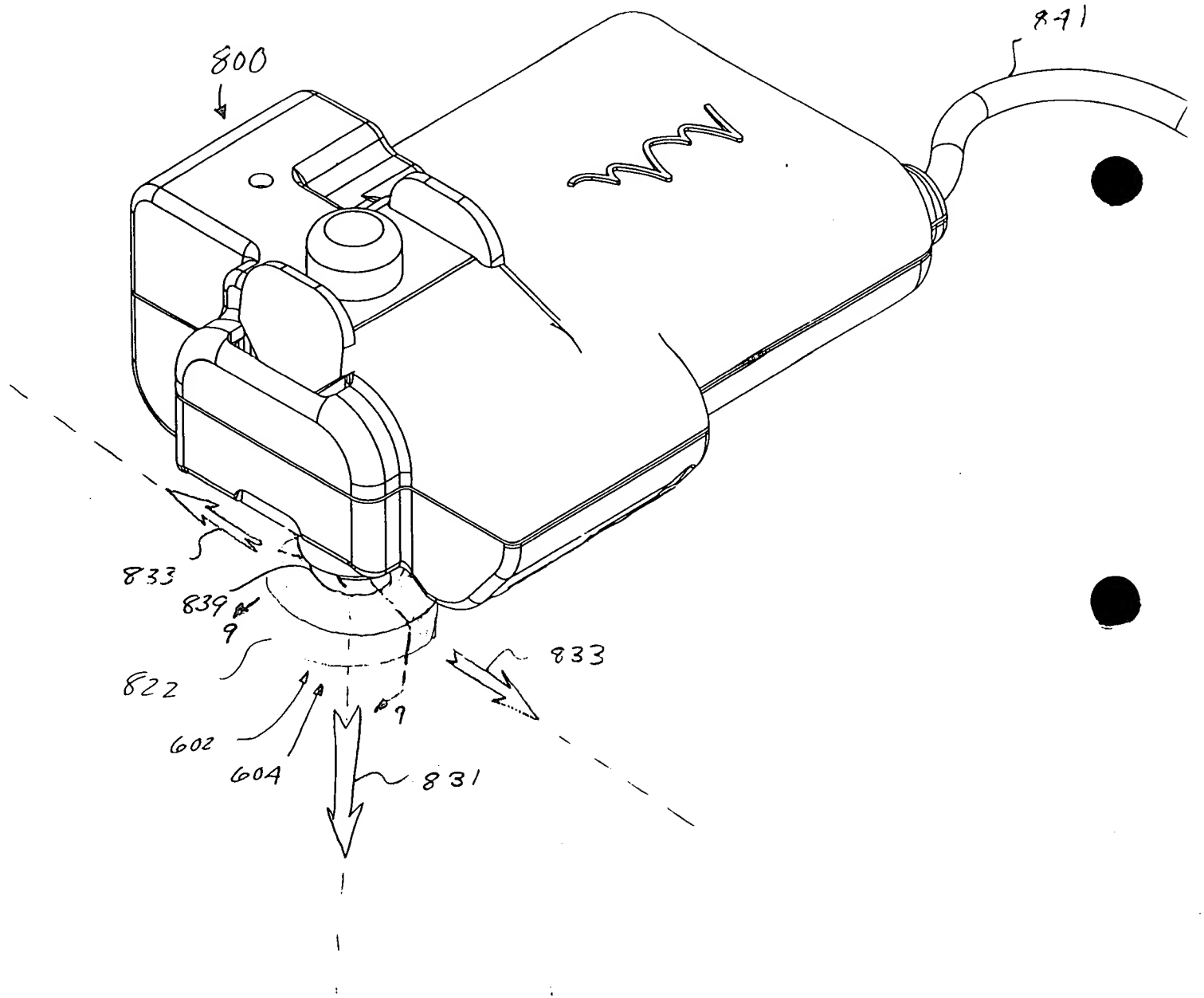
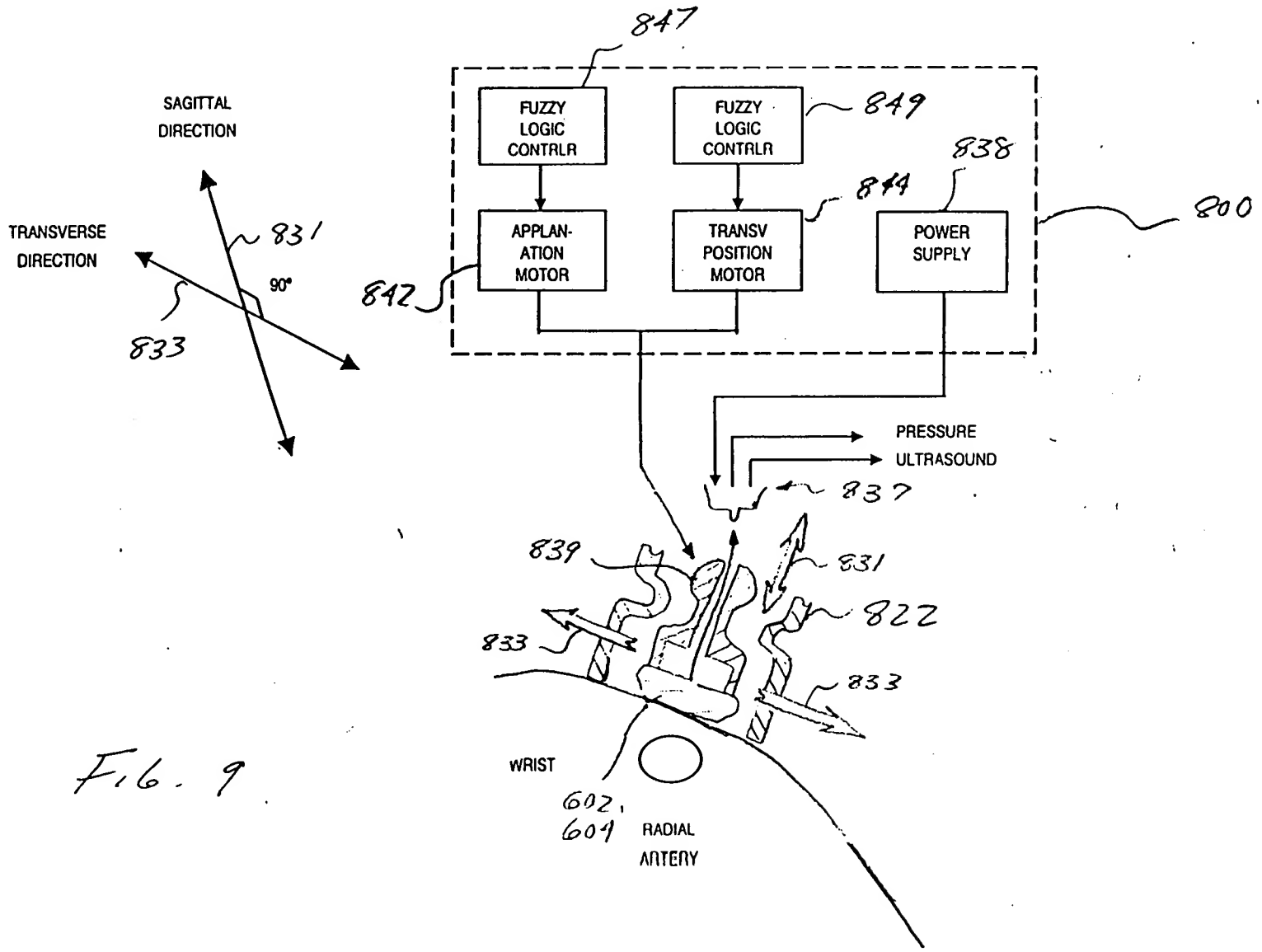


Fig. 7

F.6. 8




847
FUZZY LOGIC CONTRLR
FUZZY LOGIC CONTRLR
849
838
844
800
APPLAN-ATION MOTOR
TRANSV POSITION MOTOR
POWER SUPPLY
842
SAGITTAL DIRECTION
TRANSVERSE DIRECTION
831
90°
833
PRESSURE
ULTRASOUND
837
839
831
822
833
833
WRIST
602,
604
RADIAL ARTERY

F.16. 9

FIG. 10

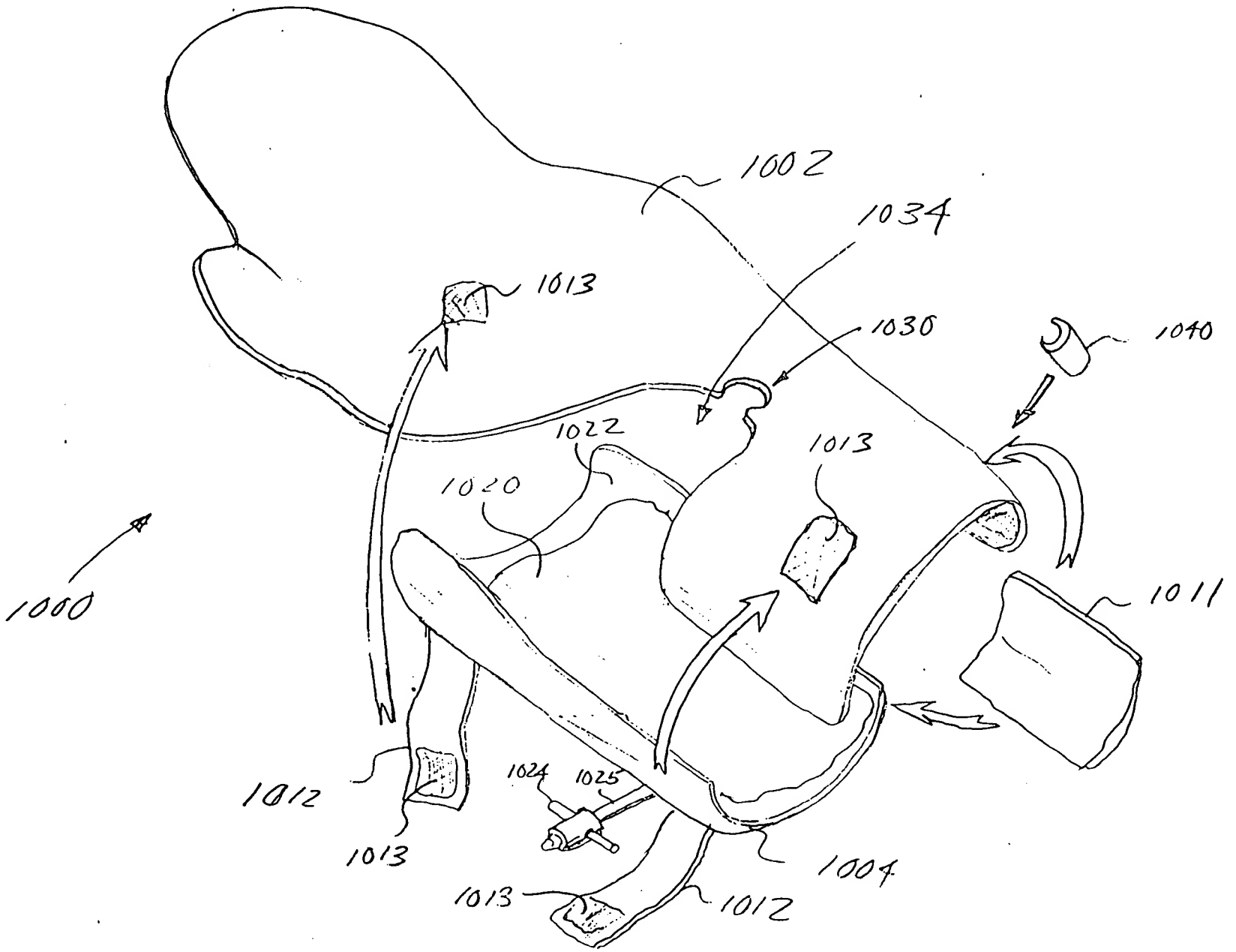

1002
1034
1013
1030
1040
1022
1013
1020
1000
1011
1012
1024
1025
1013
1004
1013
1012

FIG. 11

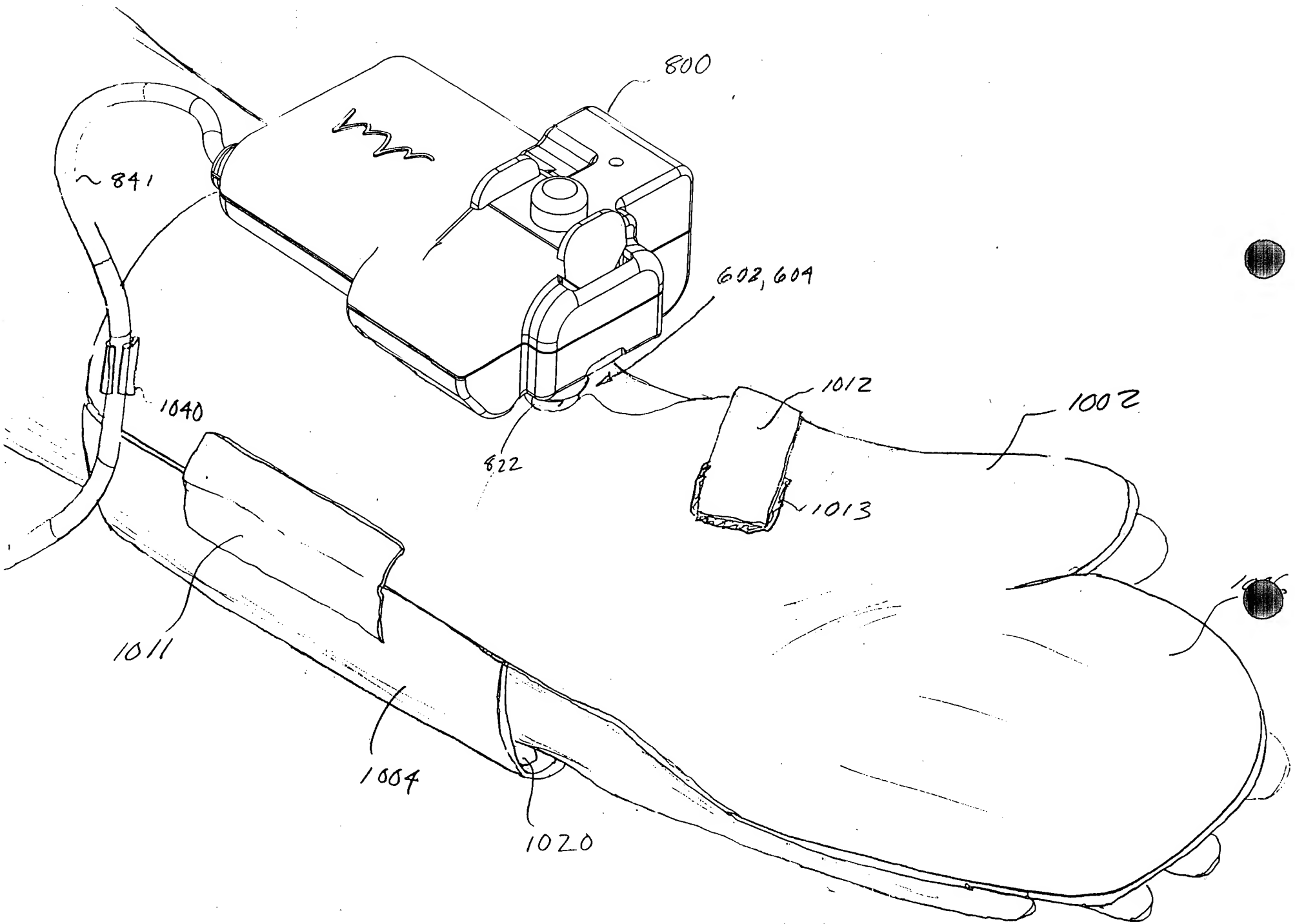
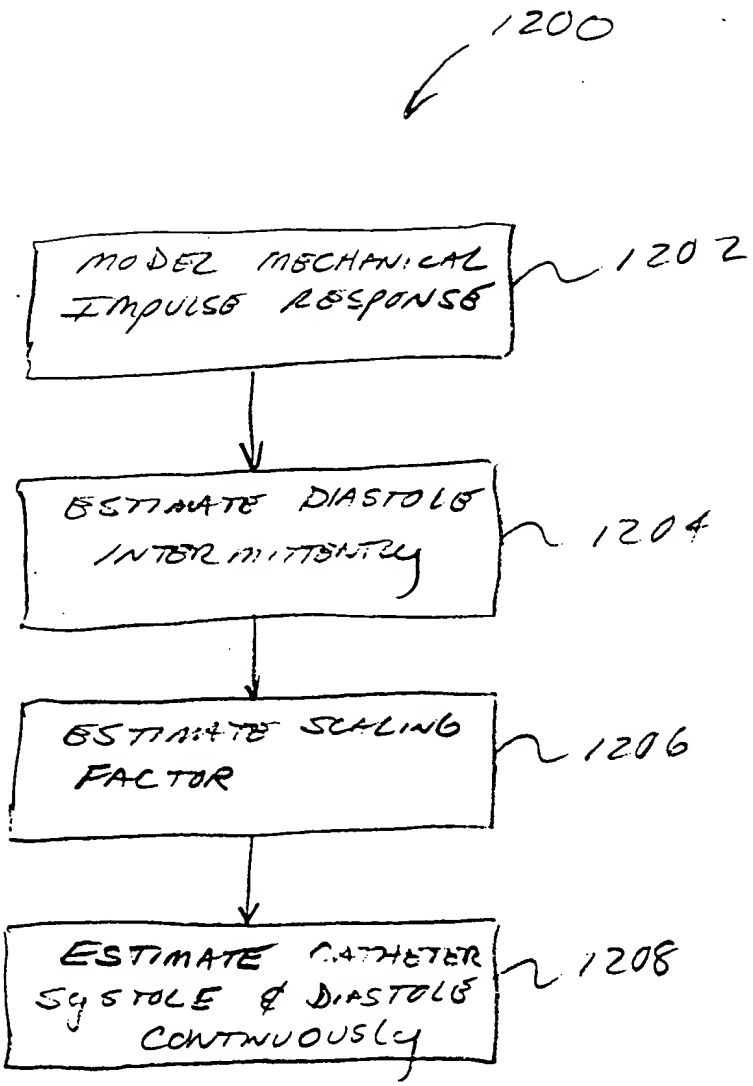


FIG. 12


1200
MODEL MECHANICAL IMPULSE RESPONSE
1202
ESTIMATE DIASTOLE INTERMITTENTLY
1204
ESTIMATE SCALING FACTOR
1206
ESTIMATE CATHETER SYSTOLE & DIASTOLE CONTINUOUSLY
1208

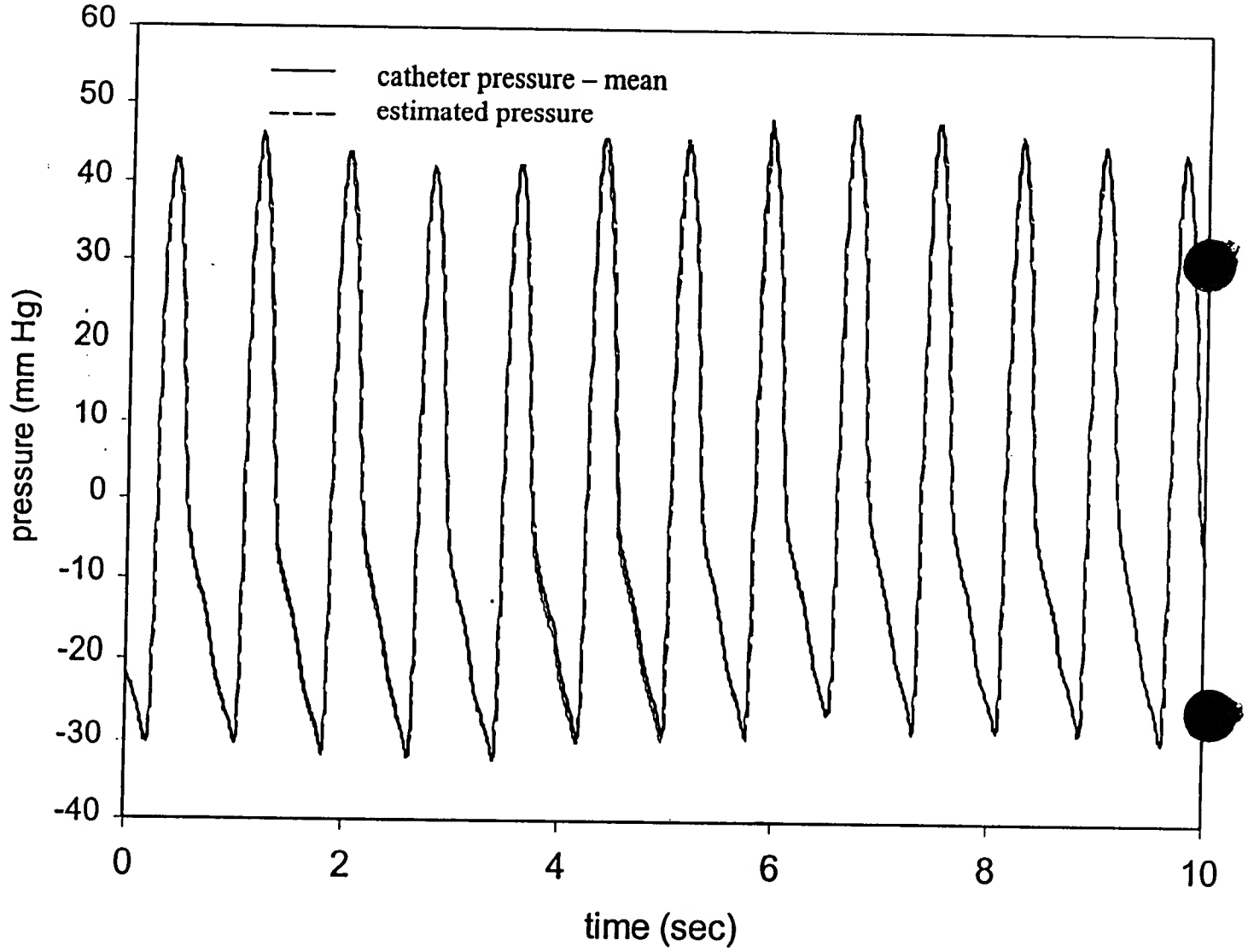

60
50
40
30
20
10
0
-10
-20
-30
-40
pressure (mm Hg)
catheter pressure – mean
estimated pressure
0
2
4
6
8
10
time (sec)

FIG. 13

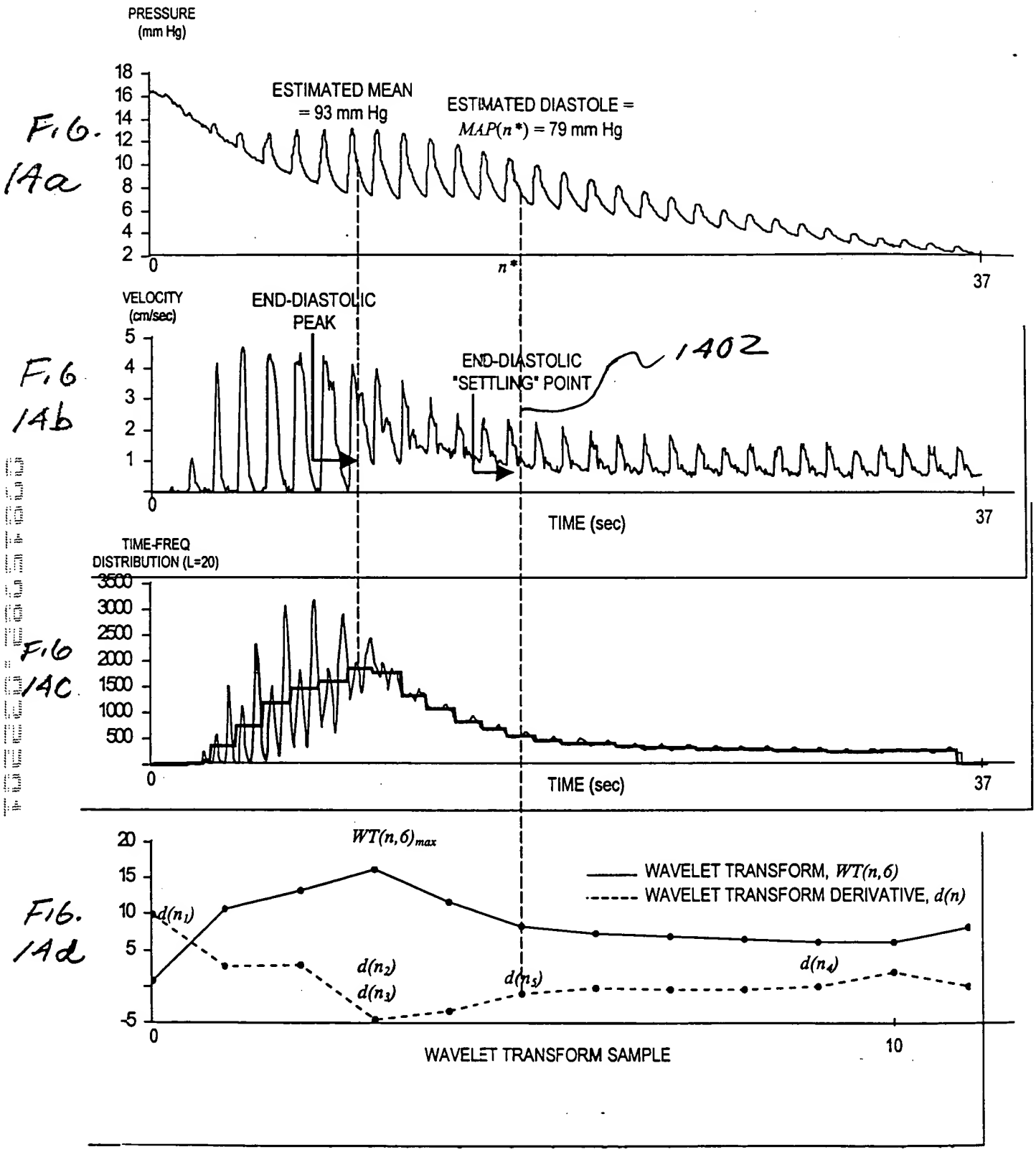


Fig. 1Aa

Fig. 1Ab

Fig. 1Ac

Fig. 1Ad

FIG. 15

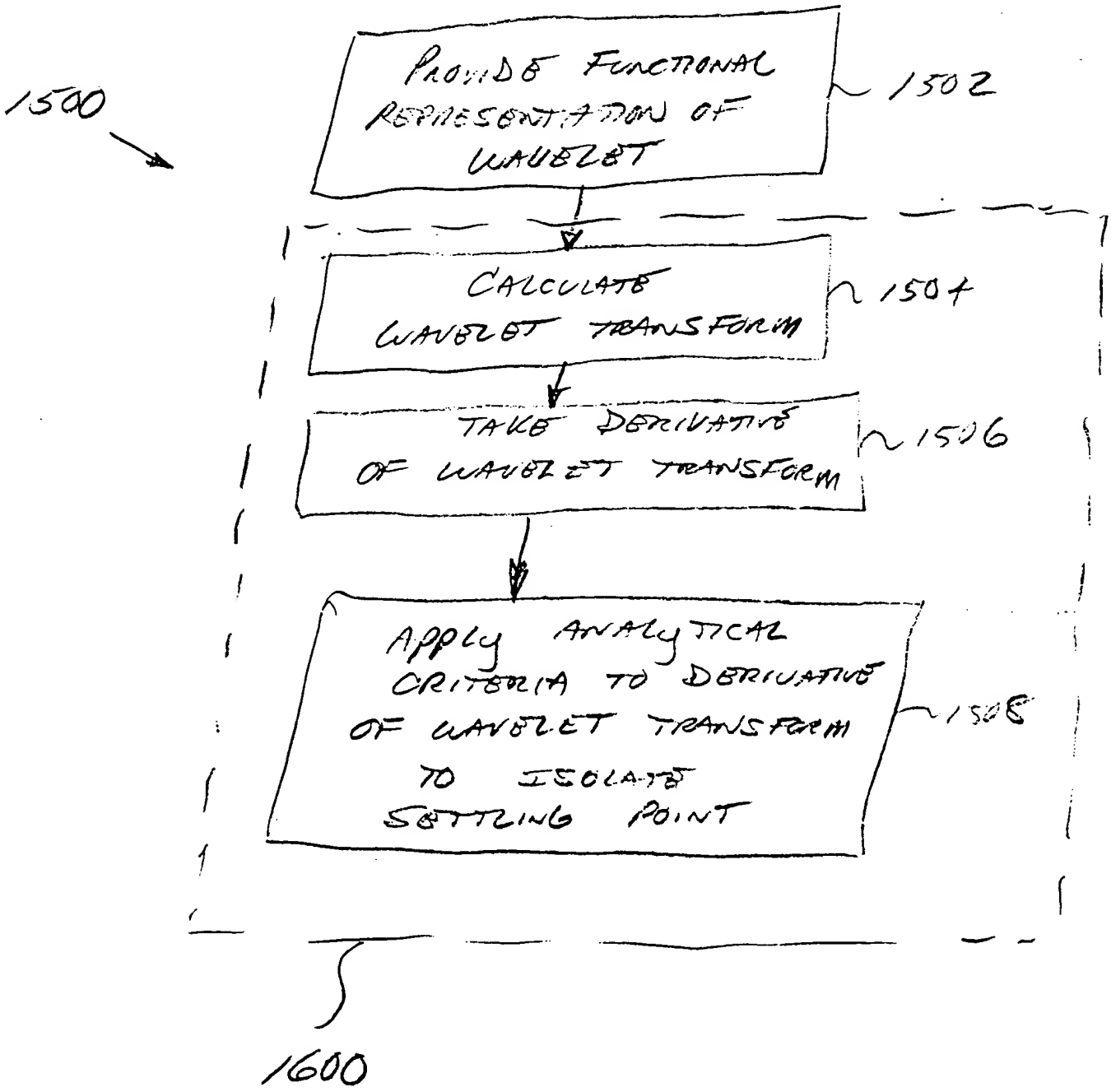
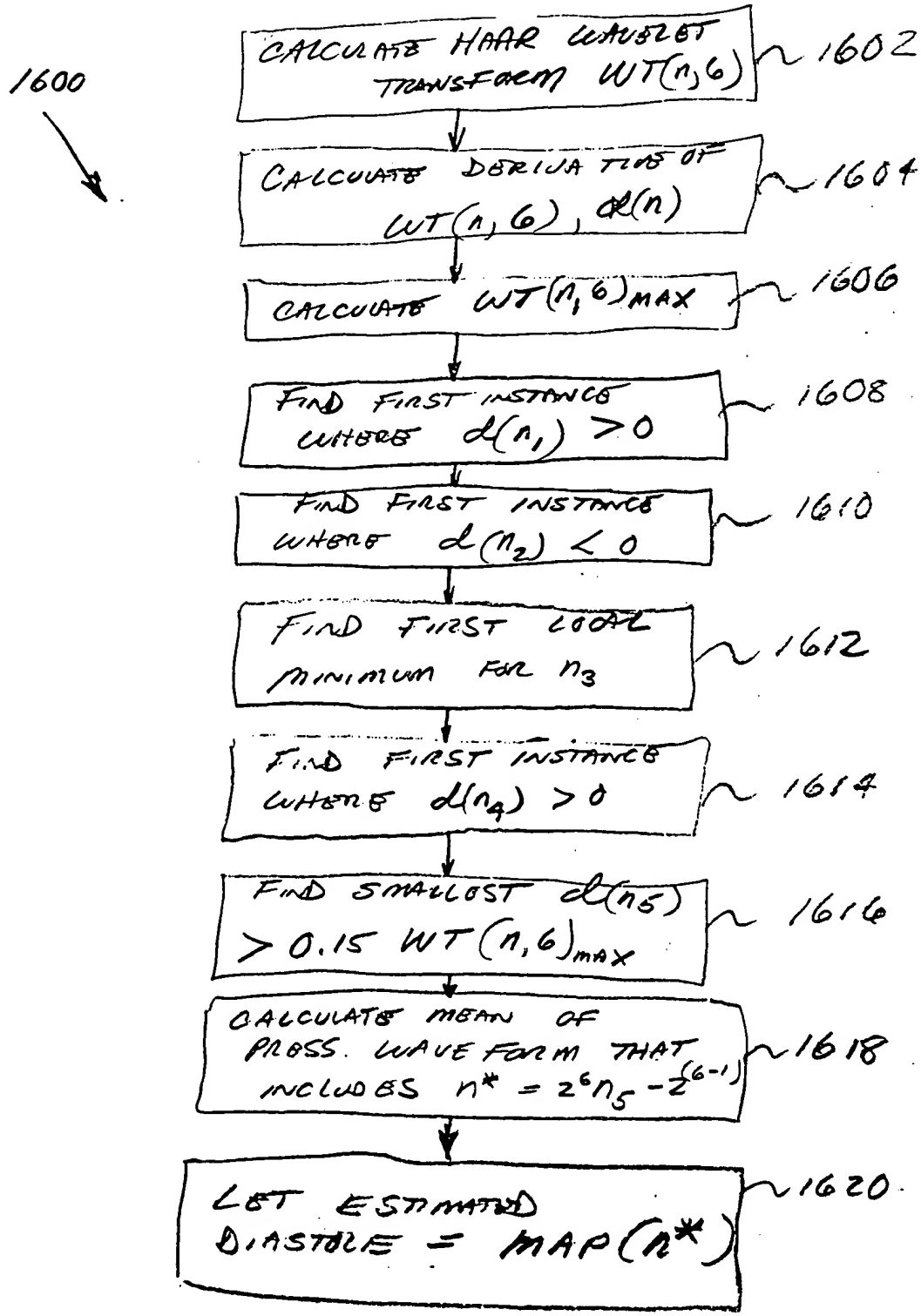

1500
PROVIDE FUNCTIONAL REPRESENTATION OF WAVELET
1502
CALCULATE WAVELET TRANSFORM
1504
TAKE DERIVATIVE OF WAVELET TRANSFORM
1506
APPLY ANALYTICAL CRITERIA TO DERIVATIVE OF WAVELET TRANSFORM TO ISOLATE SETTLING POINT
1508
1600

FIG. 16


1600
CALCULATE HAAR WAVELET TRANSFORM WT(n,6)
1602
CALCULATE DERIVATIVES OF WT(n,6), d(n)
1604
CALCULATE WT(n,6)MAX
1606
FIND FIRST INSTANCE WHERE d(n1) > 0
1608
FIND FIRST INSTANCE WHERE d(n2) < 0
1610
FIND FIRST LOCAL MINIMUM FOR n3
1612
FIND FIRST INSTANCE WHERE d(n4) > 0
1614
FIND SMALLEST d(n5) > 0.15 WT(n,6)max
1616
CALCULATE MEAN OF PROSS. WAVE FORM THAT INCLUDES n* = 2^6 n5 - 2^(6-1)
1618
LET ESTIMATED DIASTOLE = MAP(n*)
1620

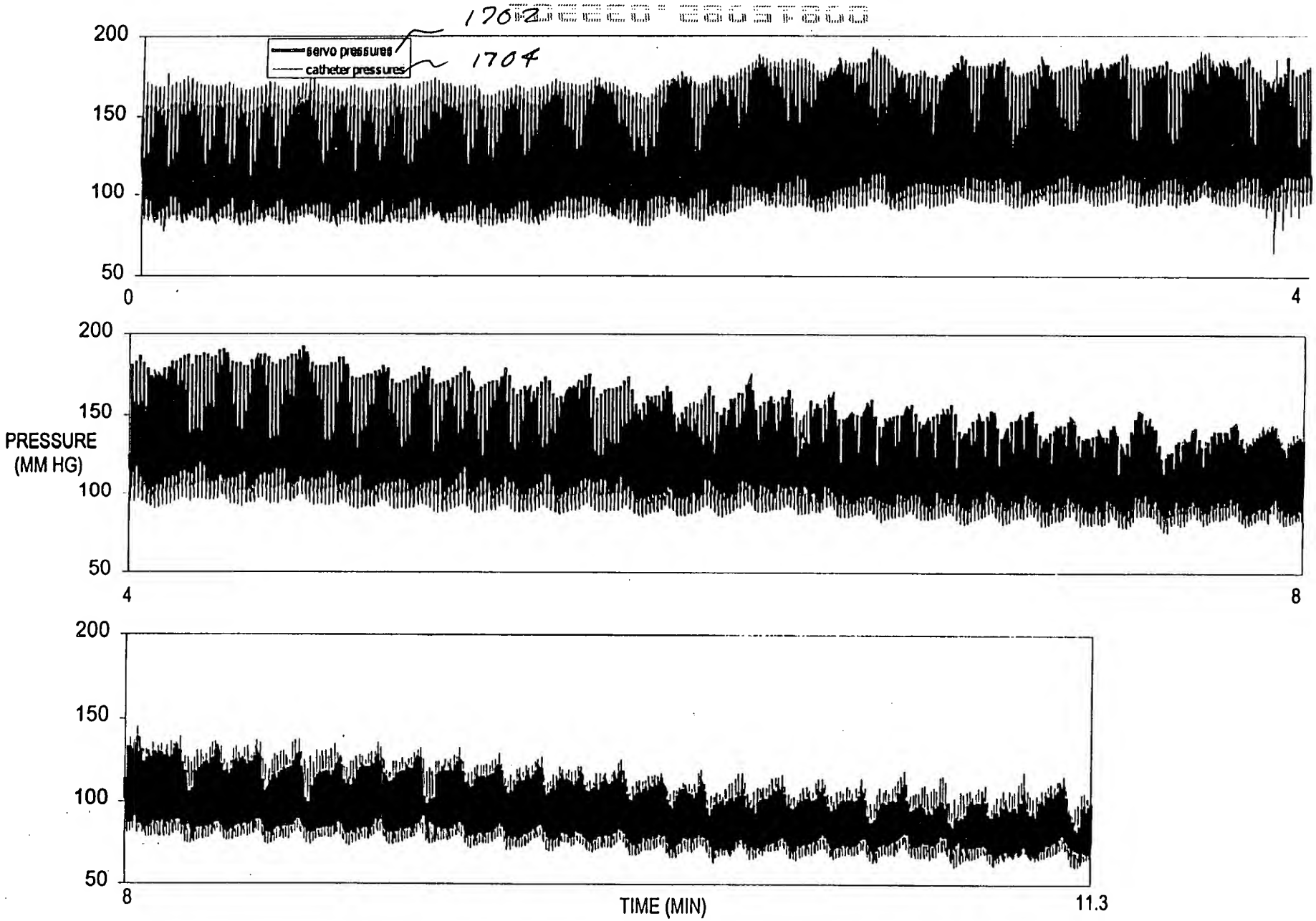
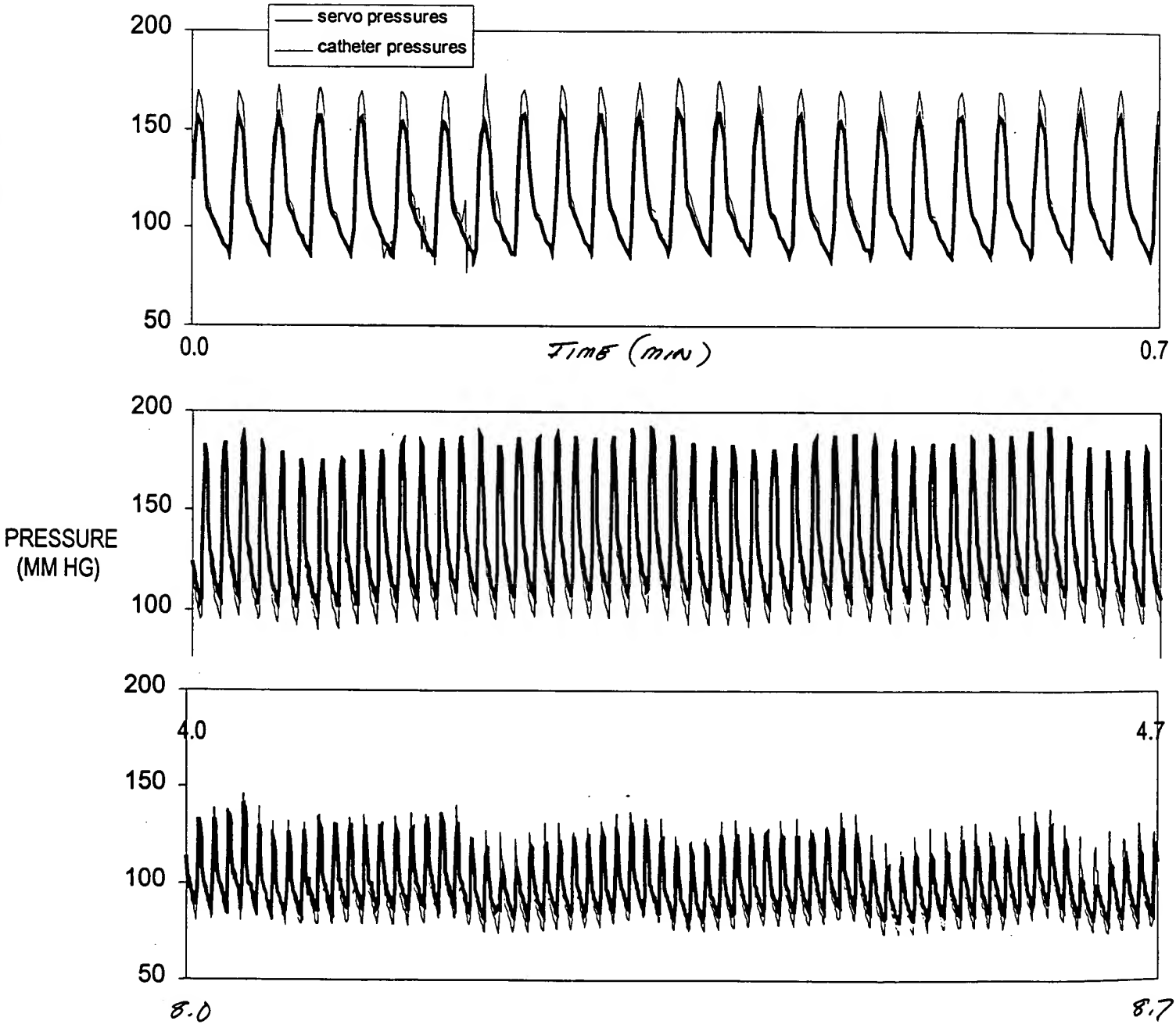

1702
1704
servo pressures
catheter pressures
200
150
100
50
0
4
8
11.3
PRESSURE (MM HG)
TIME (MIN)

FIG. 17

FIG. 18


servo pressures
catheter pressures
200
150
100
50
0.0
TIME (min)
0.7
PRESSURE
(MM HG)
200
150
100
4.0
4.7
200
150
100
50
8.0
8.7

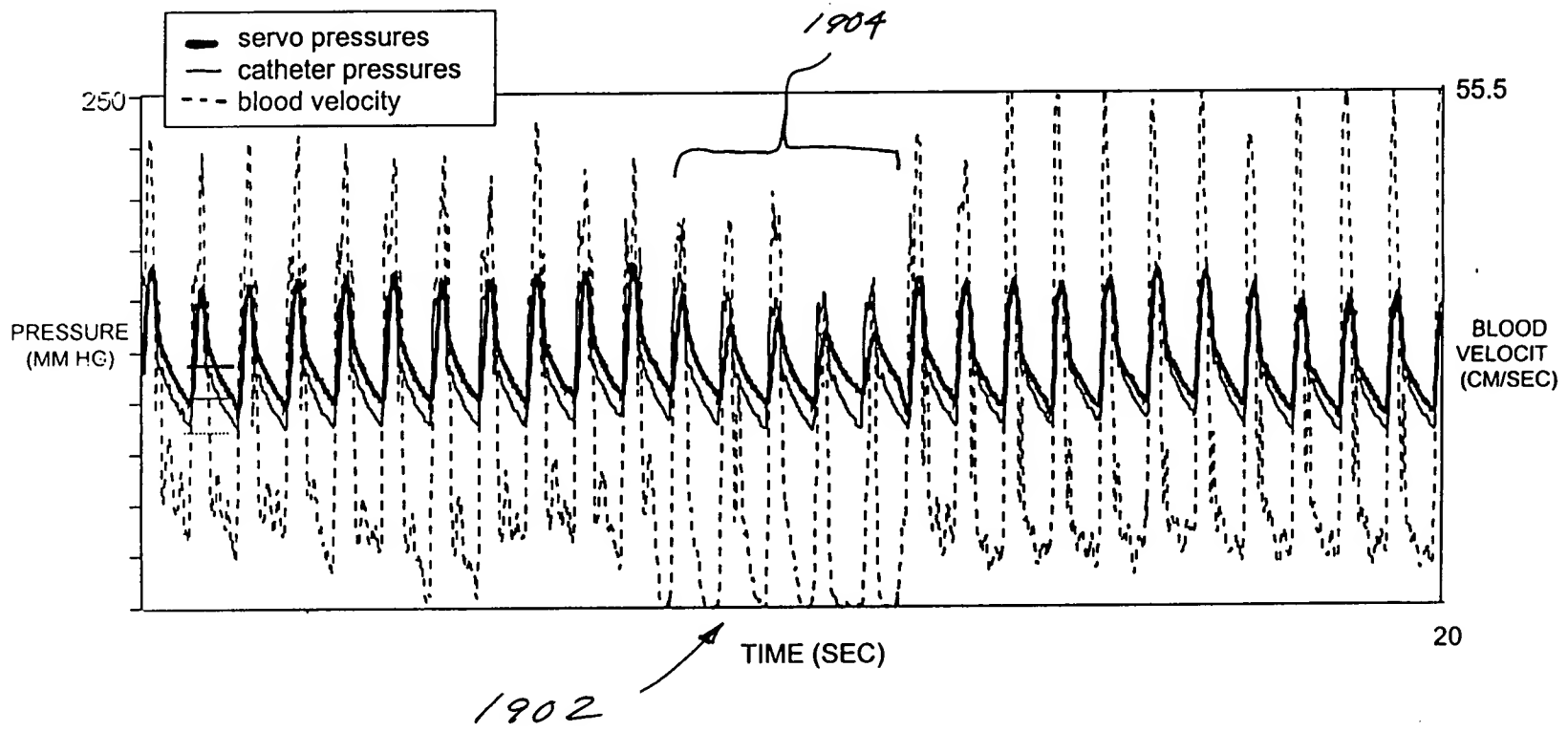

servo pressures
catheter pressures
blood velocity
1904
250
55.5
PRESSURE
(MM HG)
BLOOD
VELOCIT
(CM/SEC)
TIME (SEC)
20
1902

FIG. 19

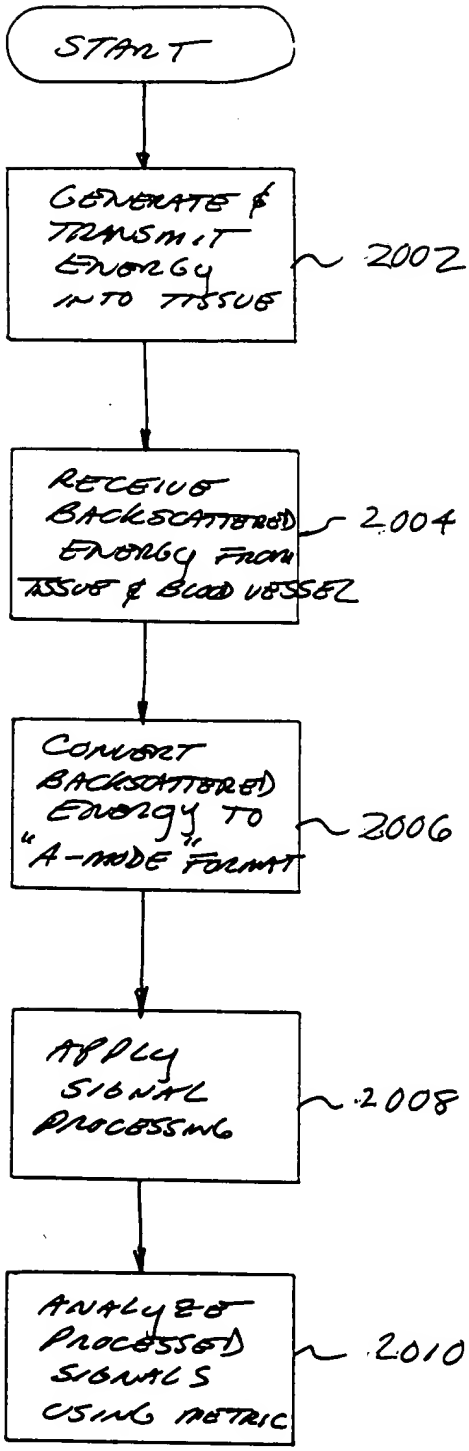
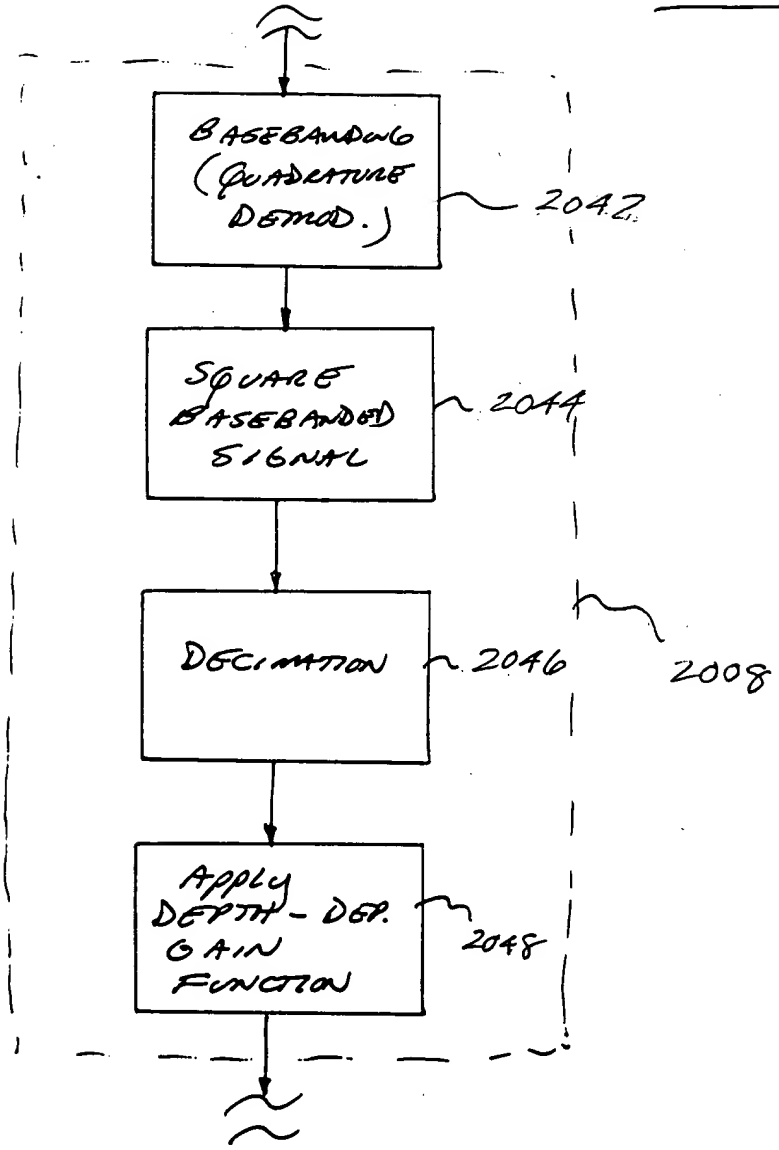

START
GENERATE & TRANSMIT ENERGY INTO TISSUE
2002
2000
RECEIVE BACKSCATTERED ENERGY FROM TISSUE & BLOOD VESSEL
2004
CONVERT BACKSCATTERED ENERGY TO "A-MODE" FORMAT
2006
APPLY SIGNAL PROCESSING
2008
ANALYZE PROCESSED SIGNALS USING METRIC
2010

FIG. 20

FIG. 20a


BASEBANDING (QUADRATURE DEMOD.)
2042
SQUARE BASEBANDED SIGNAL
2044
DECIMATION
2046
2008
APPLY DEPTH-DEP. GAIN FUNCTION
2048

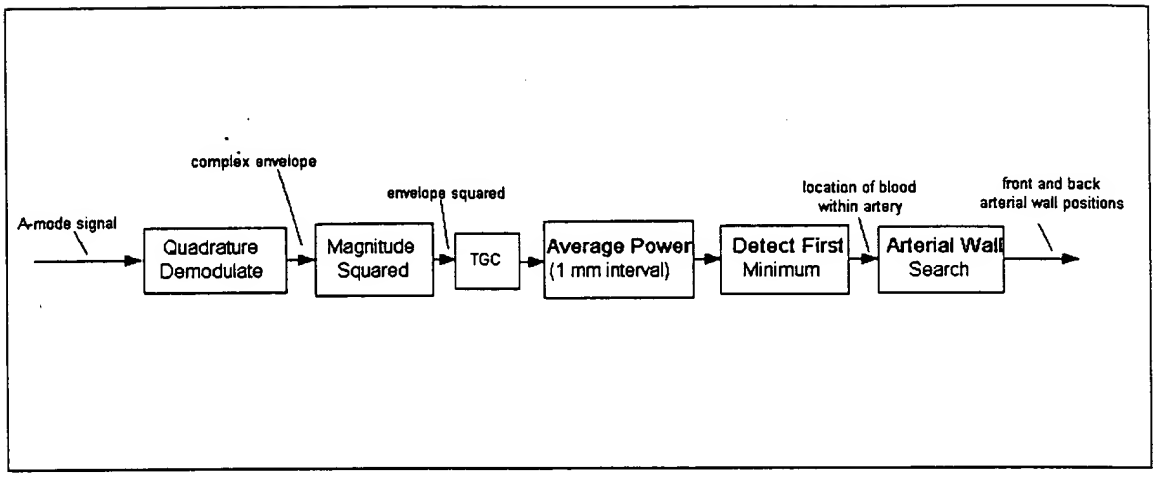

A-mode signal
Quadrature Demodulate
complex envelope
Magnitude Squared
envelope squared
TGC
Average Power (1 mm interval)
Detect First Minimum
location of blood within artery
Arterial Wall Search
front and back arterial wall positions

Fig. 3/c

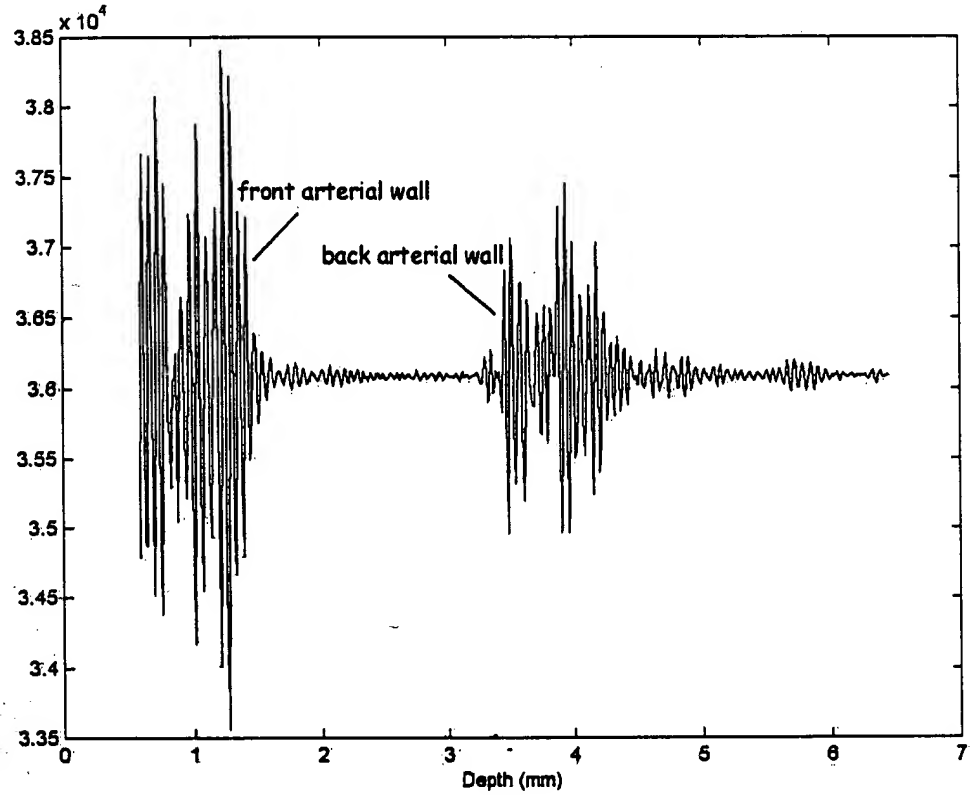

x 10^4
3.85
3.8
3.75
3.7
3.65
3.6
3.55
3.5
3.45
3.4
3.35
front arterial wall
back arterial wall
0
1
2
3
4
5
6
7
Depth (mm)

Fig. 2/

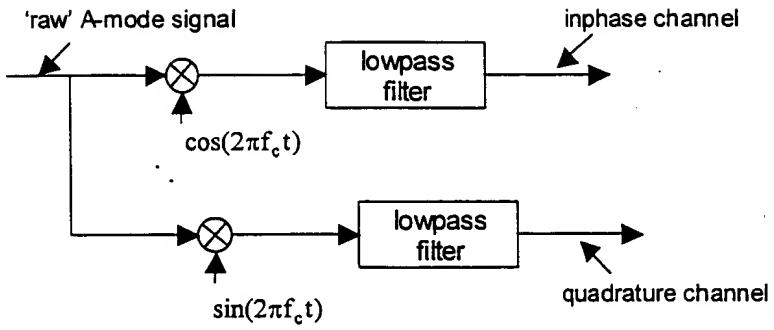

'raw' A-mode signal
inphase channel
lowpass filter
$\cos(2\pi f_c t)$
lowpass filter
quadrature channel
$\sin(2\pi f_c t)$

Fig. 24

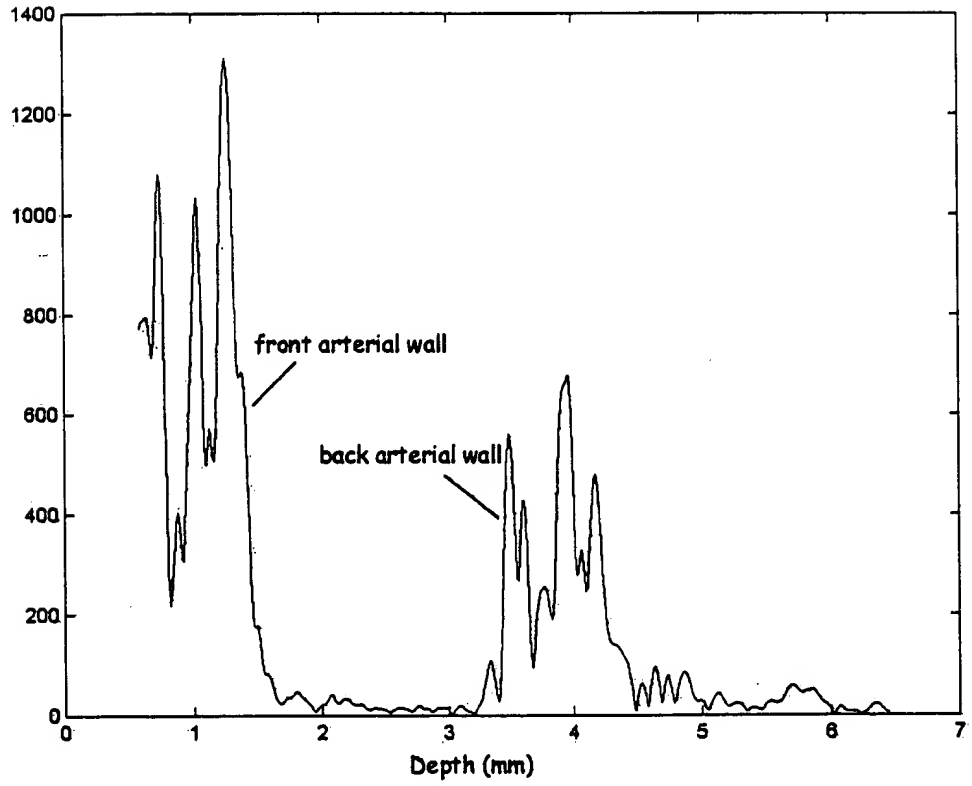

1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
front arterial wall
back arterial wall
Depth (mm)

Fig. 22

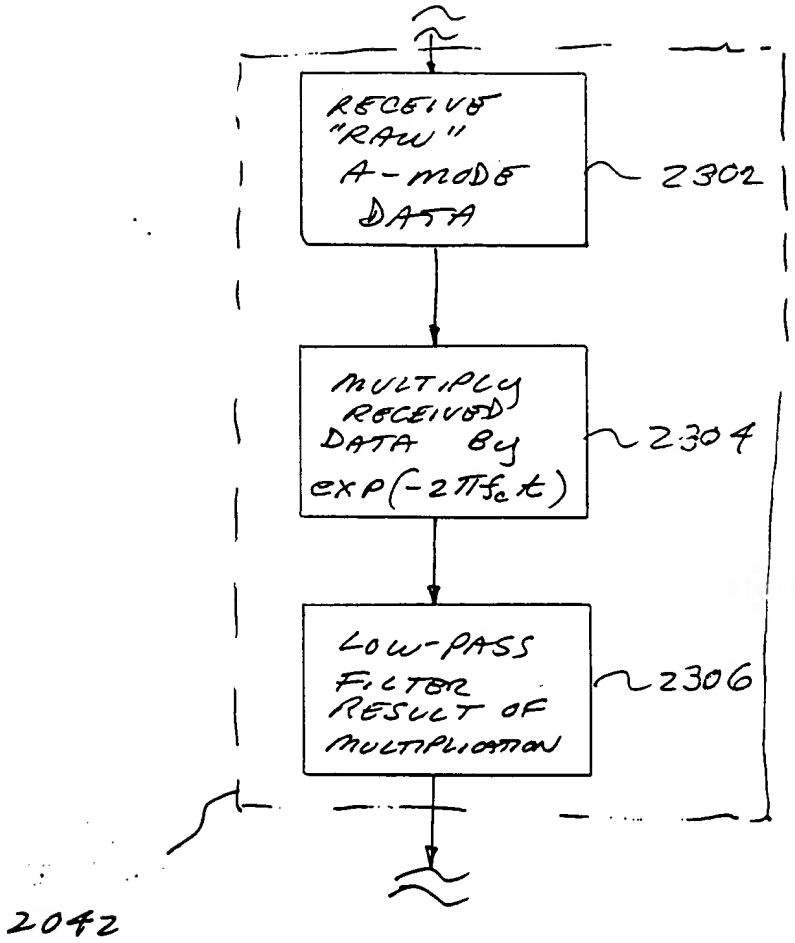

RECEIVE "RAW" A-MODE DATA
2302
MULTIPLY RECEIVED DATA BY exp(-2πf_c t)
2304
LOW-PASS FILTER RESULT OF MULTIPLICATION
2306
2042

FIG. 23

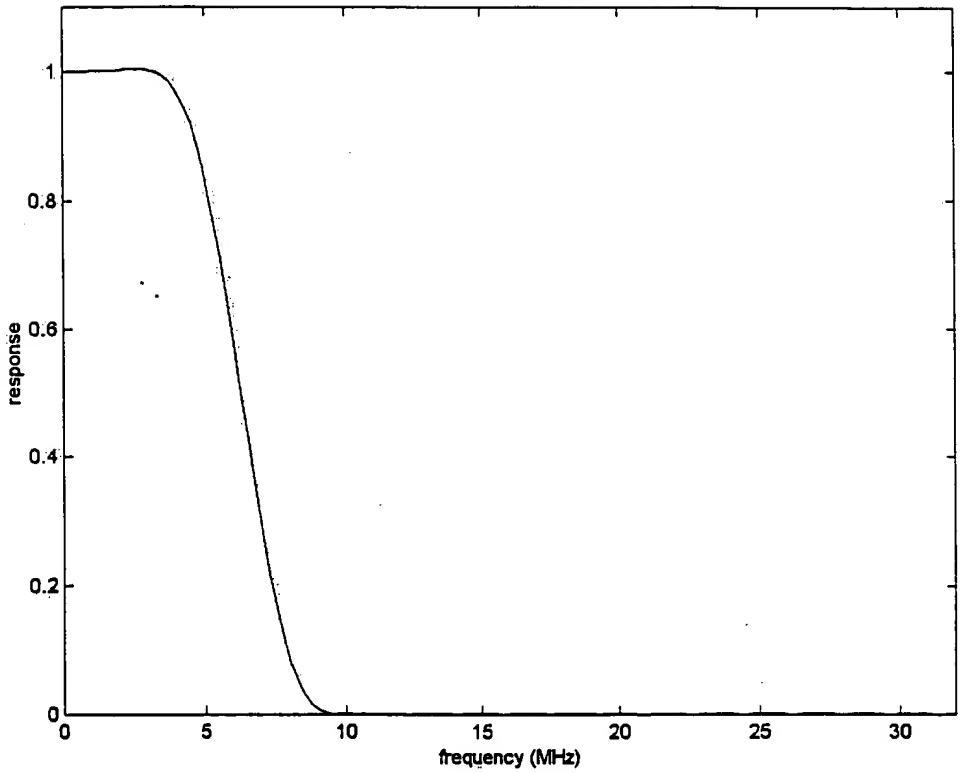


Fig. 25

-1
-1
0
2
4
6
6
2
-6
-16
-25
-26
-16
10
50
98
143
176
188
176
143
98
50
10
-16
-26
-25
-16
-6
6
6
6
4
2
0
-1
-1

FIG. 26

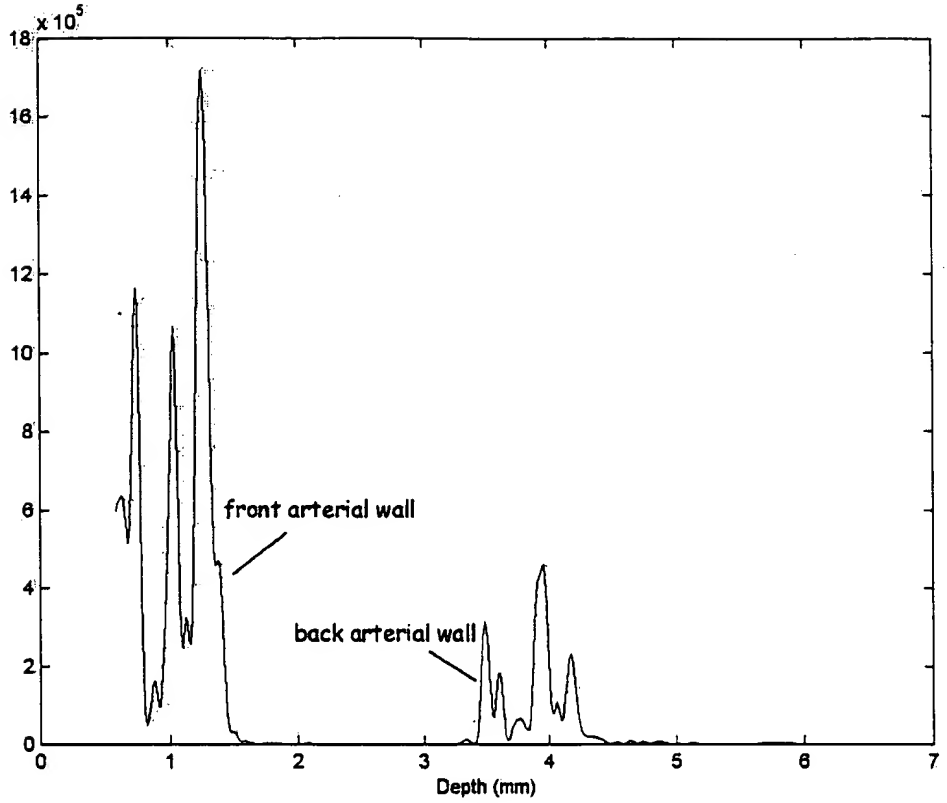

x 10^5
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
Depth (mm)
front arterial wall
back arterial wall

Fig. 27

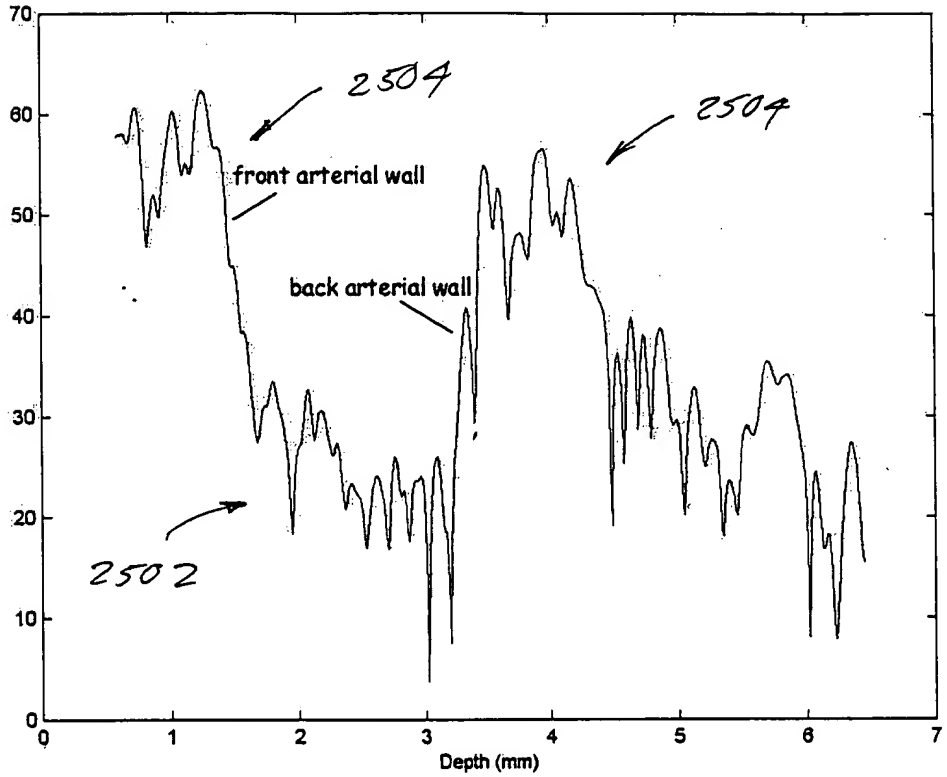

2504
2504
front arterial wall
back arterial wall
2502
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
Depth (mm)

Fig. 28

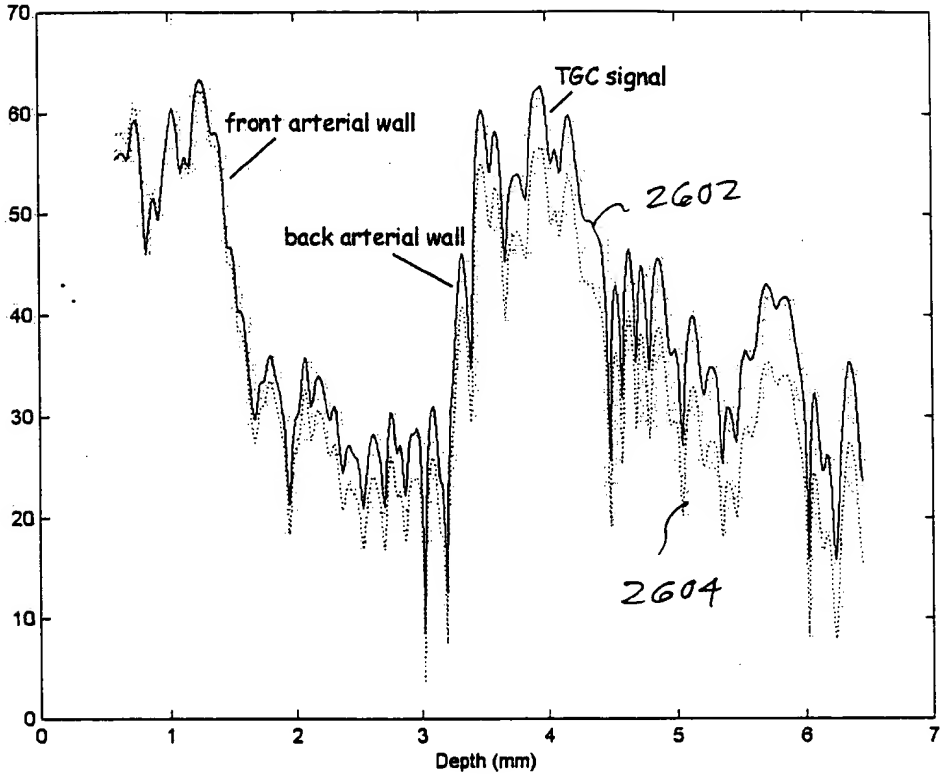

70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
Depth (mm)
front arterial wall
back arterial wall
TGC signal
2602
2604

Fig. 29

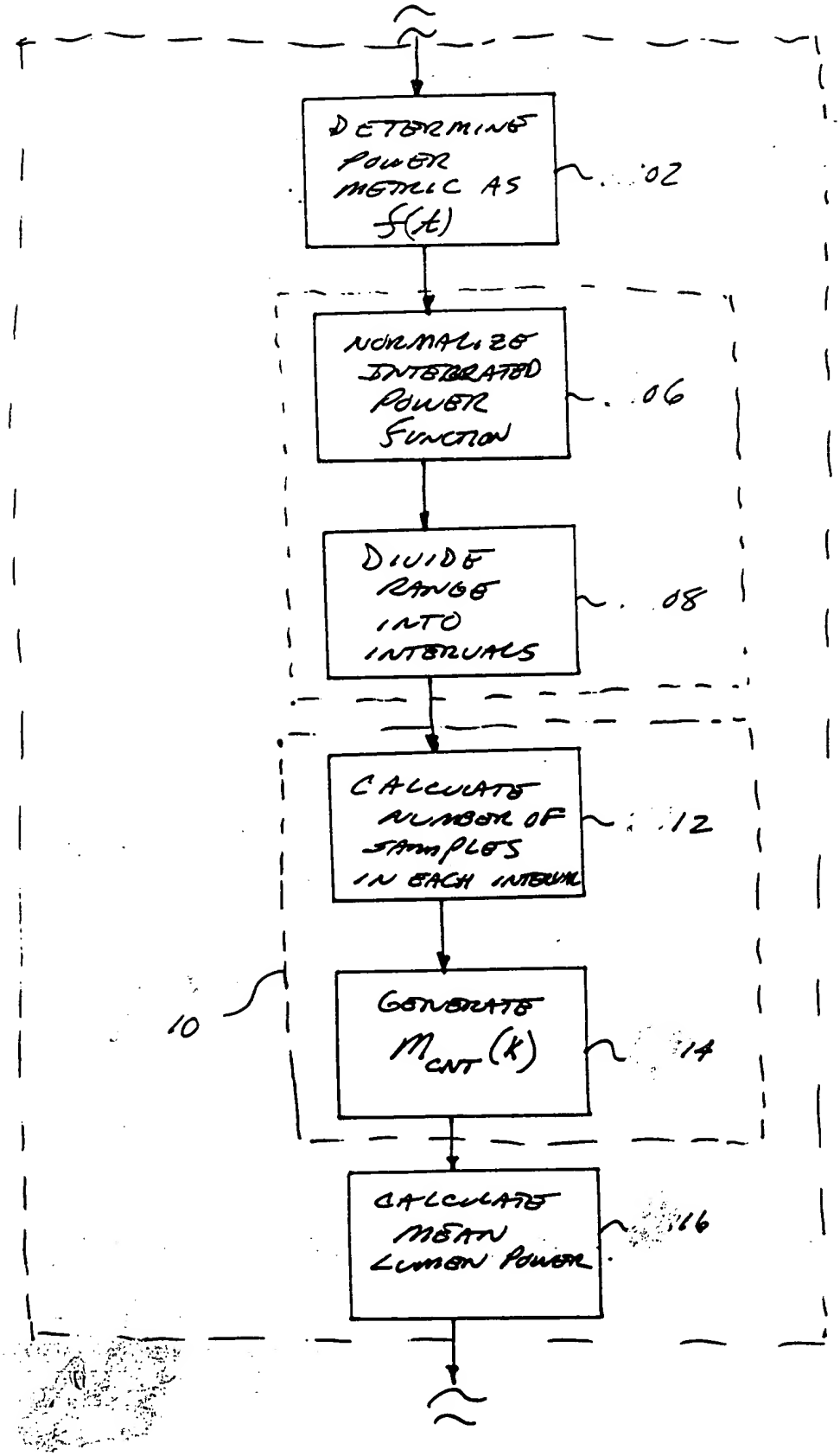

DETERMINE POWER METRIC AS f(t)
02
NORMALIZE INTEGRATED POWER FUNCTION
06
DIVIDE RANGE INTO INTERVALS
08
CALCULATE NUMBER OF SAMPLES IN EACH INTERVAL
12
GENERATE $M_{CNT}(k)$
14
CALCULATE MEAN LUMEN POWER
16
10

FIG. 3a

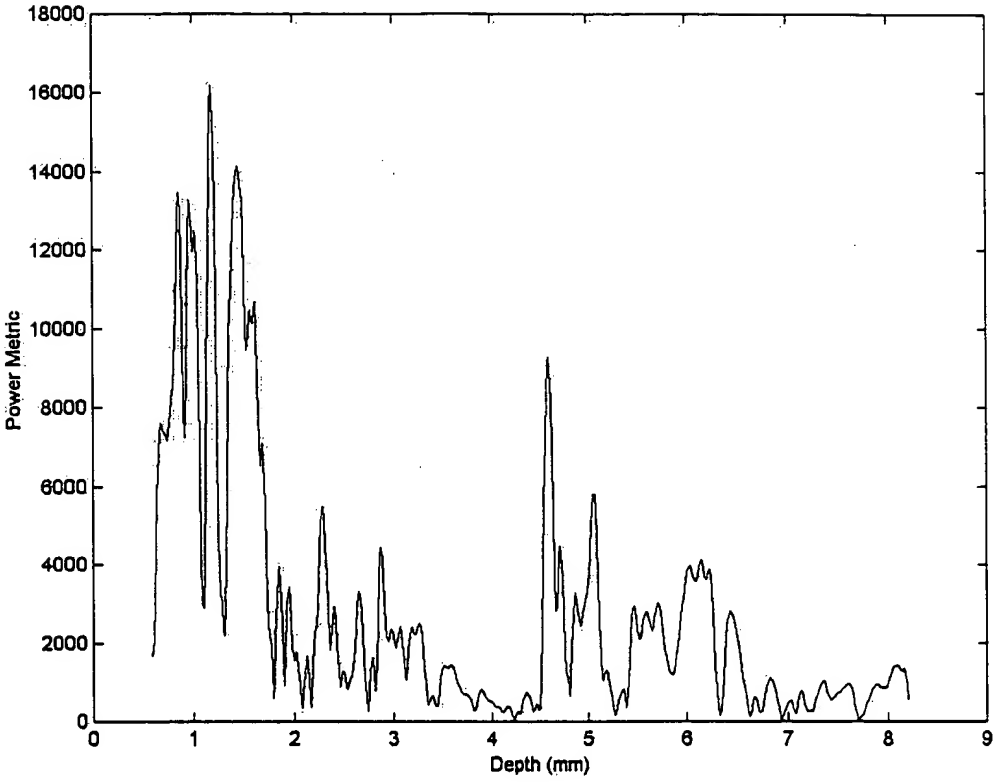

18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Power Metric
0
1
2
3
4
5
6
7
8
9
Depth (mm)

Fig. 306

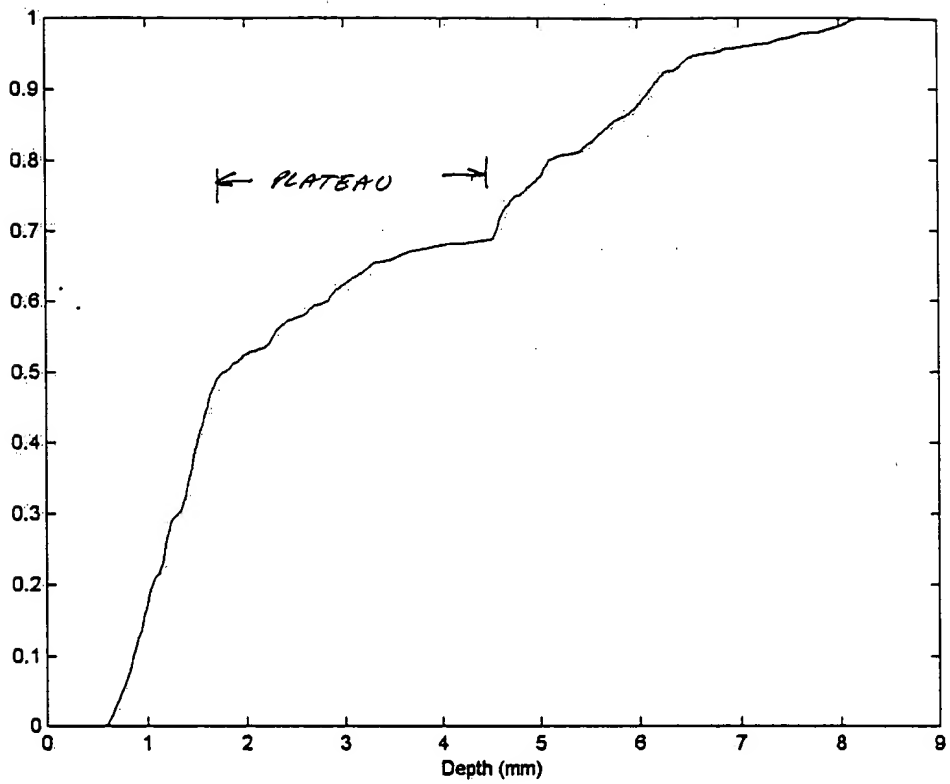


Fig. 30c

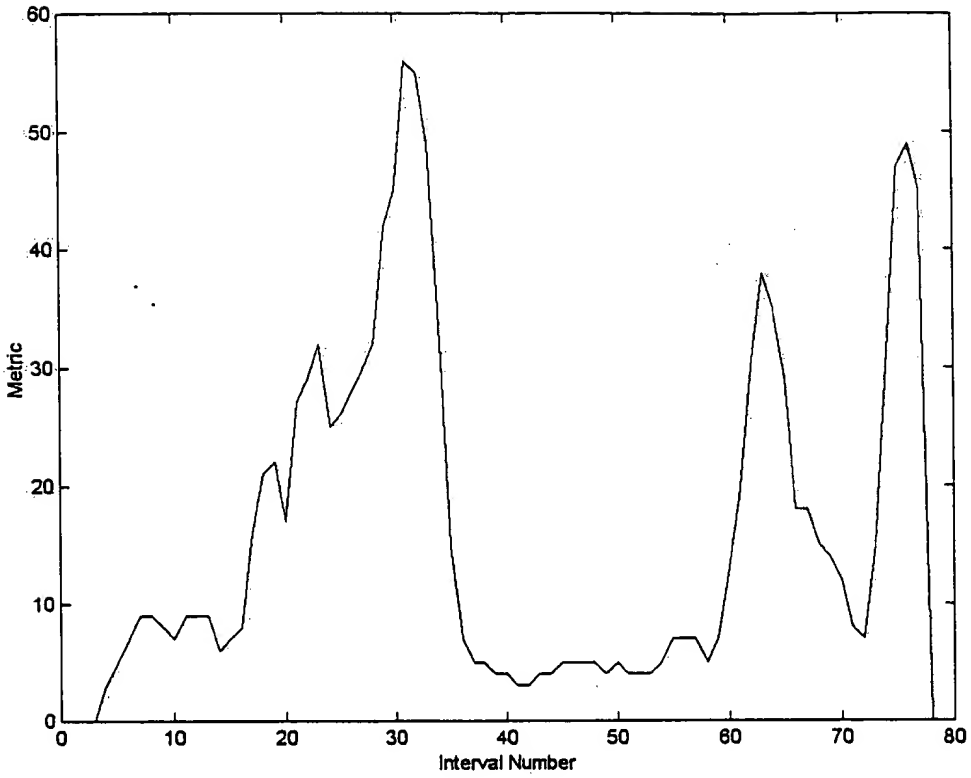


Fig. 30d

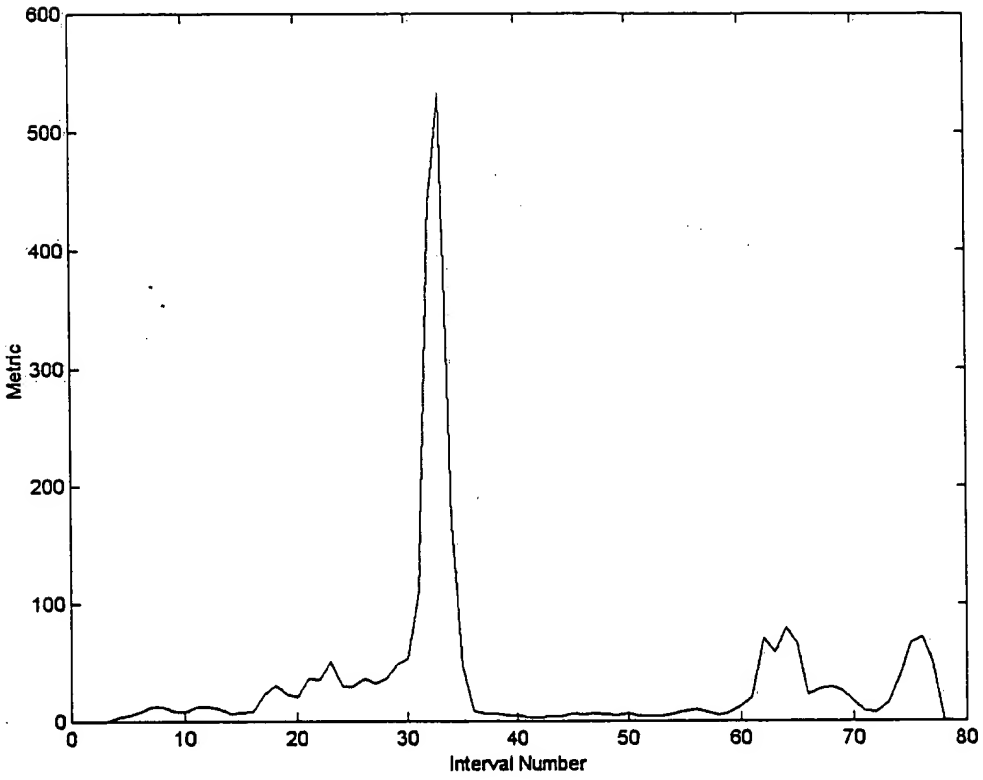

600
500
400
300
200
100
0
Metric
0
10
20
30
40
50
60
70
80
Interval Number

Fig. 30e

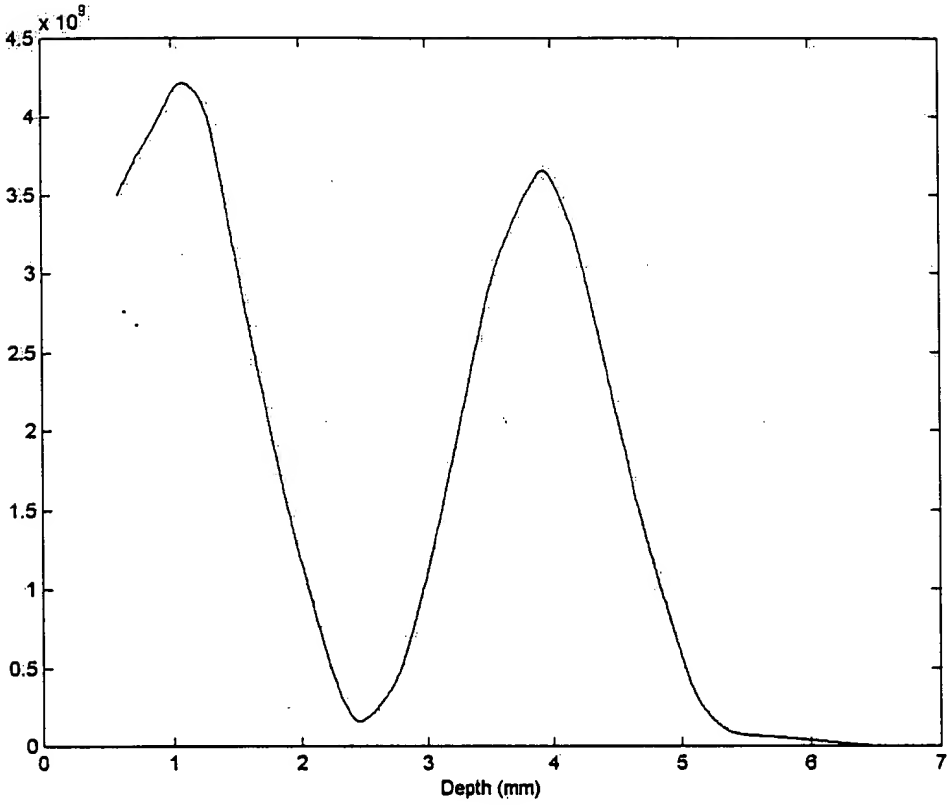


Fig. 3/a

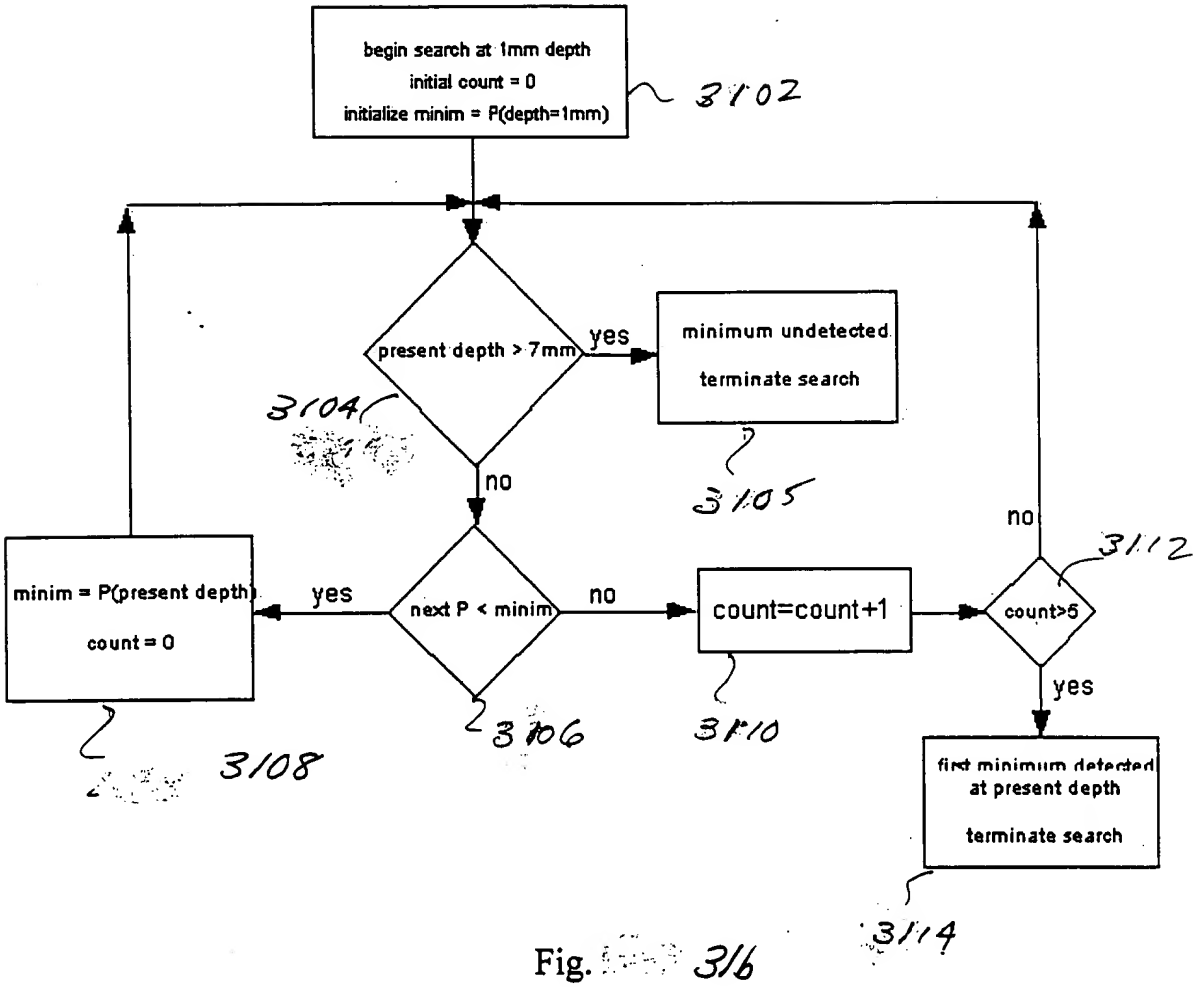

begin search at 1mm depth
initial count = 0
initialize minim = P(depth=1mm)
3102
present depth > 7mm
yes
minimum undetected
terminate search
3104
3105
no
minim = P(present depth)
count = 0
yes
next P < minim
no
count=count+1
count>5
no
3112
yes
first minimum detected
at present depth
terminate search
3108
3106
3110
3114

Fig. 3/6

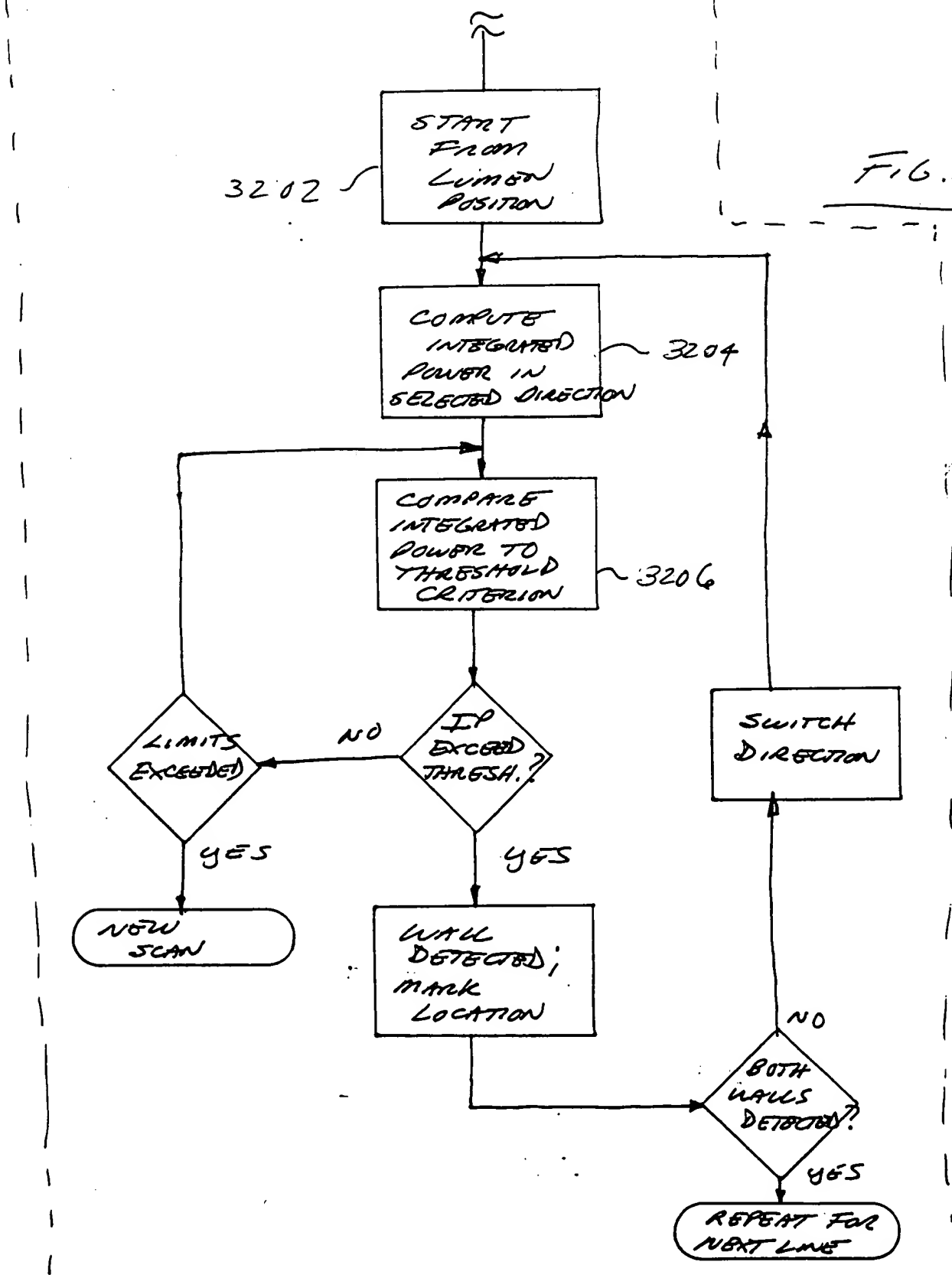

START FROM LUMEN POSITION
3202
COMPUTE INTEGRATED POWER IN SELECTED DIRECTION
3204
COMPARE INTEGRATED POWER TO THRESHOLD CRITERION
3206
IF EXCEED THRESH.?
NO
YES
LIMITS EXCEEDED
YES
NEW SCAN
WALL DETECTED; MARK LOCATION
SWITCH DIRECTION
BOTH WALLS DETECTED?
NO
YES
REPEAT FOR NEXT LINE

FIG. 32

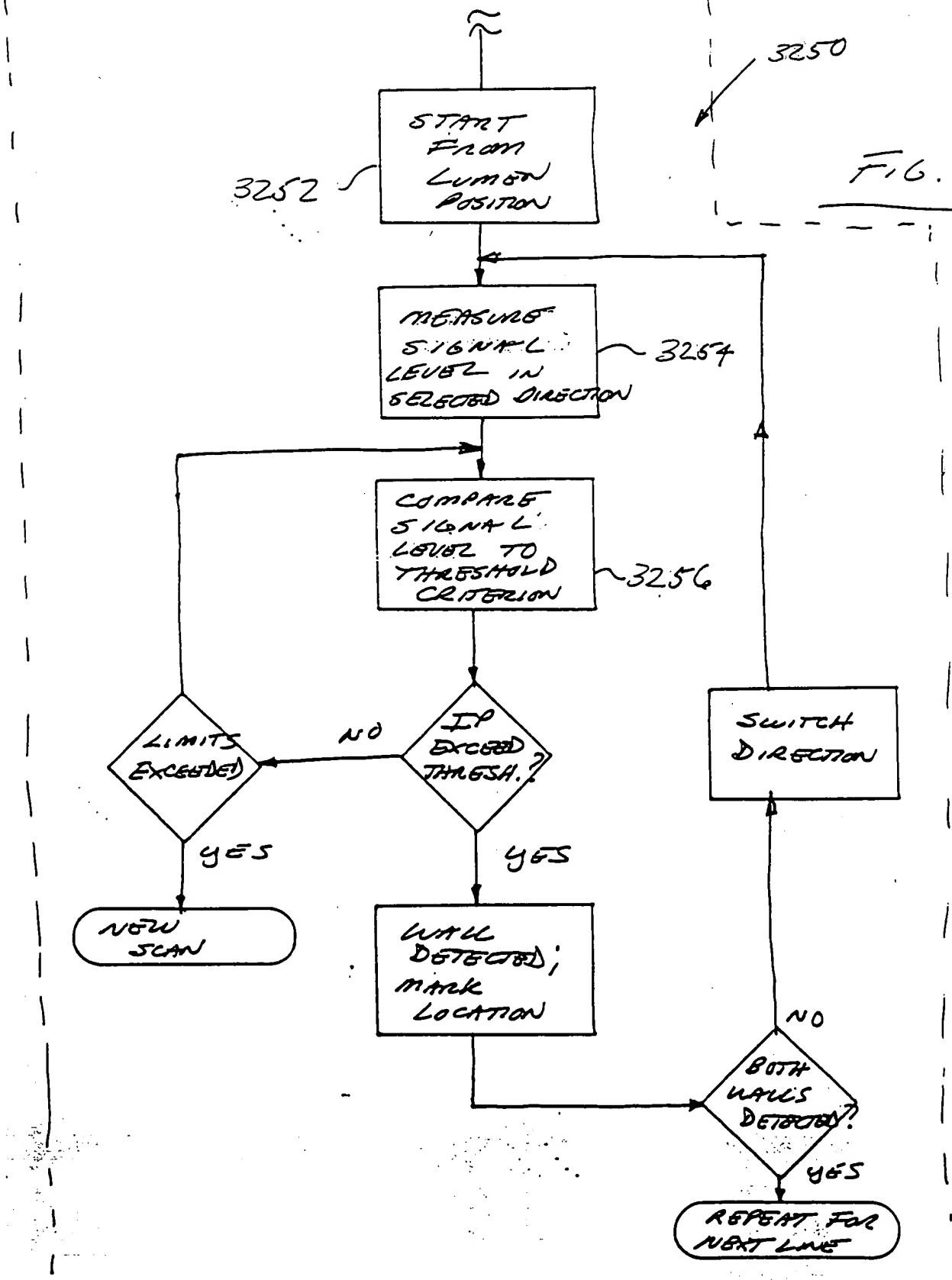

3250
START FROM LUMEN POSITION
3252
MEASURE SIGNAL LEVEL IN SELECTED DIRECTION
3254
COMPARE SIGNAL LEVEL TO THRESHOLD CRITERION
3256
IF EXCEED THRESH.?
NO
LIMITS EXCEEDED
YES
NEW SCAN
YES
WALL DETECTED; MARK LOCATION
SWITCH DIRECTION
NO
BOTH WALLS DETECTED?
YES
REPEAT FOR NEXT LINE

FIG. 32b

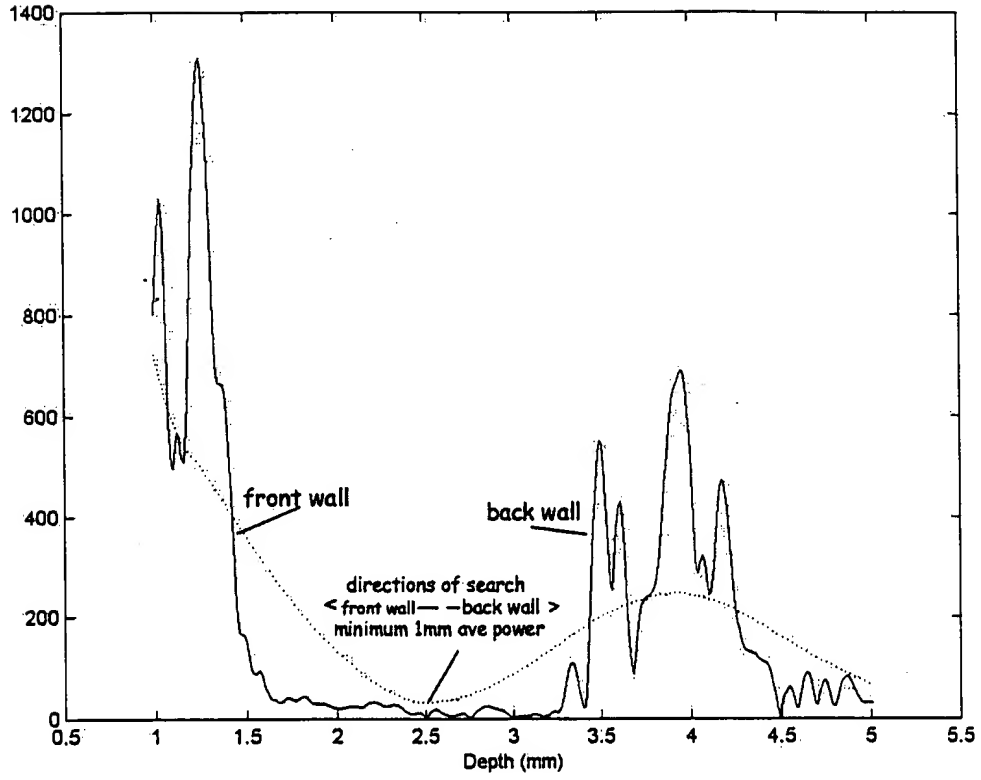

1400
1200
1000
800
600
400
200
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
Depth (mm)
front wall
back wall
directions of search
< front wall— —back wall >
minimum 1mm ave power

Fig. 33

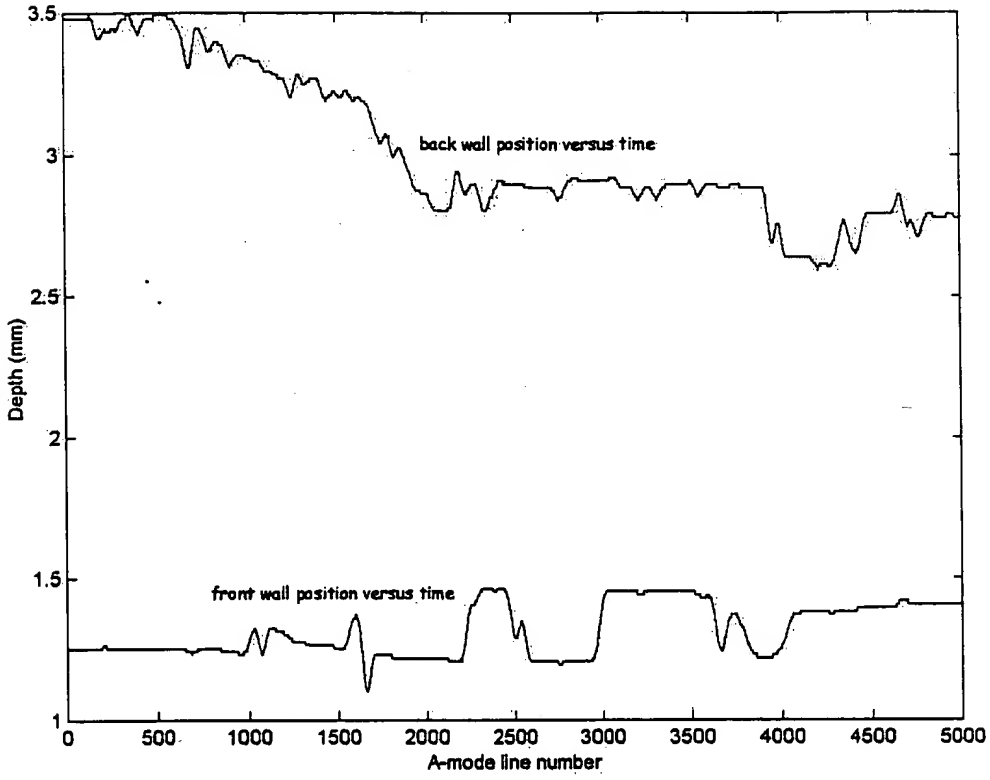

back wall position versus time
front wall position versus time
Depth (mm)
A-mode line number
3.5
3
2.5
2
1.5
1
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000

Fig. 34

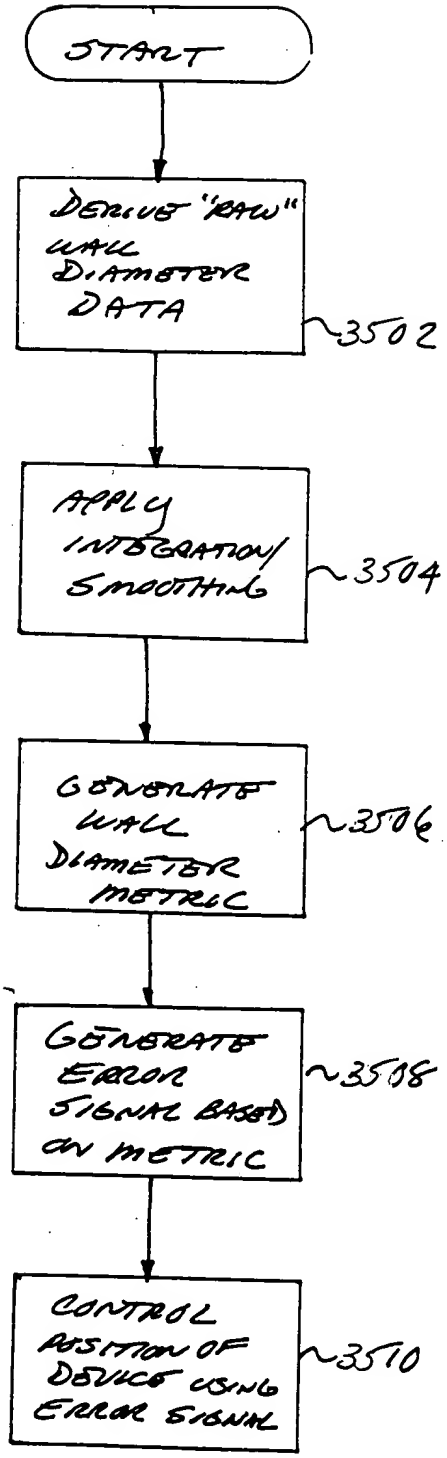

START
DERIVE "RAW" WALL DIAMETER DATA
3502
APPLY INTEGRATION/ SMOOTHING
3504
GENERATE WALL DIAMETER METRIC
3506
GENERATE ERROR SIGNAL BASED ON METRIC
3508
CONTROL POSITION OF DEVICE USING ERROR SIGNAL
3510

FIG. 35

3500